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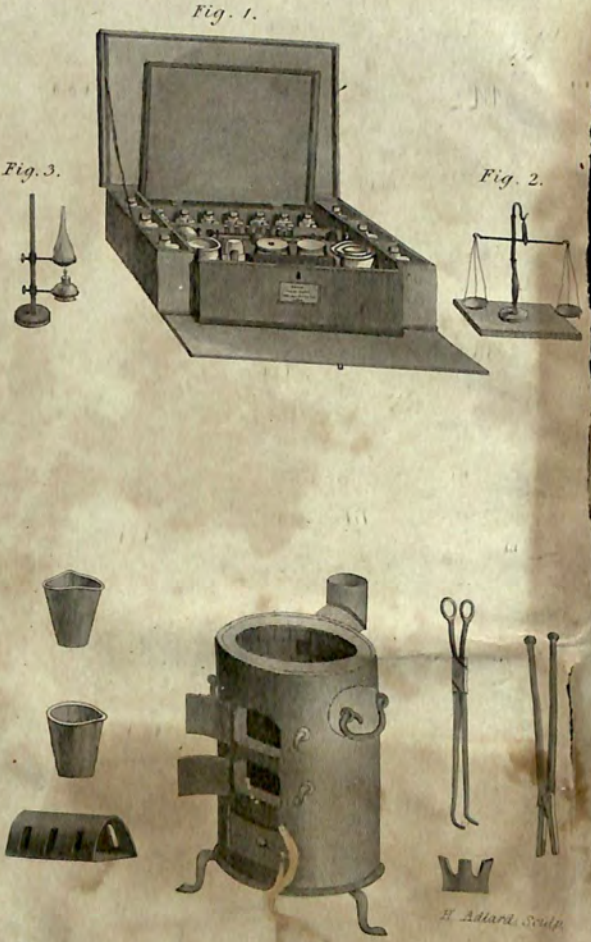

APPARATUS

USED IN CHEMICAL MINERALOGY.

PRACTICAL CHEMICAL

MINERALOGY.

BY

Frederick Joyce,

Operative Chemist,

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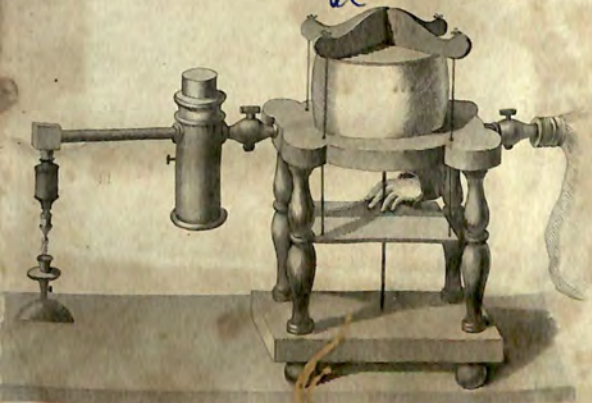

BLOW PIPE.

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PRACTICAL

CHEMICAL MINERALOGY;

OR,

CONCISE AND EASY METHODS,

ILLUSTRATED BY EXPERIMENT,

FOR READILY ASCERTAINING THE NATURE AND VALUE OF THE DIFFERENT METALLIC ORES AND OTHER MINERAL SUBSTANCES,

AS COMPREHENDED IN THEIR

ASSAY, ANALYSIS, REDUCTION, &c.

TOGETHER WITH

A DESCRIPTION OF THE APPARATUS AND TESTS USED BY THE SCIENTIFIC MINERALOGIST, AND THE PROCESSES ADOPTED BY THE PRACTICAL MINER; THE WHOLE INTENDED AS A COMPANION TO THE TRAVELLER AND THE MINERALOGICAL CABINET.

BY FREDERICK JOYCE,

OPERATIVE CHEMIST, &c.

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PREFACE.

THE rapidly increasing importance of Mineralogical Chemistry, or the Art of Assaying and Analysing Minerals, would be in itself a sufficient apology for sending forth the following pages to the world, as an endeavour to extend the knowledge of its utility, had they not also been repeatedly solicited by many of those friends to whom I have given practical instruction.

At a time when Science and Art are so intimately connected with the necessaries, as well as the elegancies, of life, it may appear to a cursory observer difficult to point at one branch in particular as possessing more advantages than the rest: nevertheless, to the man of fortune, of landed estate, and leisure, this is certainly the most intimately

connected with his interest, as to him it opens a source of wealth and rational pleasure, hitherto but too much neglected.

When it is remembered that beneath the surface of the British Isles is found the greater portion of all the more valuable metals used in our manufactories, it is not too much for such individuals to expect one of them within their own reach; yet where this is not immediately the case, the knowledge and gratification acquired will more than compensate for the time and trouble employed in the experiments necessary to this important investigation, which will, undoubtedly, ultimately lead to very beneficial national results.

I am induced to draw these conclusions from my own experience of the laudable anxiety to become acquainted with the different products of their estates, manifestly increasing amongst country gentlemen in many parts of the kingdom, who have honoured me by submitting speci-

mens for examination, which cannot fail to disseminate that taste for useful science so eminently distinguishing the present, and which must influence future generations. Having these objects in view, I have written this little Work; and, independent of its being an accompaniment to the Mineralogical Chest, or Portable Laboratory, though I do not flatter myself I have succeeded in the minutiæ to the extent of my wishes or designs, I do hope that, to the general reader, it will not be entirely unprofitable, whilst the amateur will find the methods at present employed in these arts, perspicuously but concisely explained, and which will save him the trouble of frequent reference to more elaborate works. I would particularly call the attention of the student to the description of the various operations, instruments, and tests without which nothing correct can be with certainty expected from his experiments; but by making himself thoroughly acquainted with these, and the processes enumerated, he

will find the path of science smooth and easy, and will be enabled to discriminate, with exactness, between the results of the different operations.

F. JOYCE.

11, Old Compton-street, Soho.

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PRACTICAL

CHEMICAL MINERALOGY.

A BRIEF description of the methods to be adopted, and also of the different instruments necessary for conducting the various operations employed in the examinations of mineral substances, will now be given before we proceed directly to analysis.

To chemically examine any mineral, it is first requisite that its particles should be so far separated from one another, that they may each come in contact with the particles of such other substances as are applied to effect its reduction; and these in analytical mineralogy are either acids or alkalies. To illustrate this by an example, we have nothing to do but to immerse a lump of any ore containing metal in a strong acid, and we shall find that

the action, although it may be considerable at first, will cease, or go on with extreme difficulty long before its solvent power is gone, which arises from silicious, or earthy matter, insoluble in the acid, coming in the way and resisting its energy: if now the lump is reduced to fine powder and again immersed in the same acid, the action will be renewed, those particles being exposed which it is the object of the process to dissolve.

If, therefore, by the action of an acid (see Digestion) the constituent parts of a mineral are so much divided or acted upon, as to be permanently suspended in a fluid, we can then easily, by the reaction of certain other substances, called tests or re-agents, separate any one or more of its parts from the rest by their relative affinity, for the latter being greater than for the menstruum with which it was united; thus, if a sixpence is digested in pure nitric acid, the particles of metal will be separated from each other, and a solution will take place; a change has also been produced, for if the fluid be evaporated down to dryness, the silver will not be left in the metallic state as when first put into the acid, but in the form

of a nitrated oxyde (lunar caustic); by increasing the heat the acid and oxygen will be driven off, leaving the silver behind. If, however, instead of the desiccations just alluded to, a piece of clean iron or zinc be immersed, the silver will be at once regained in the metallic state, and only altered by being in a minute state of division, instead of a lump, and this is owing to the acid taking a preference to, or, chemically speaking, having a stronger affinity for the former than the latter.

In many cases the metal, after solution, cannot be thrown down in the metallic state; when this happens the quantity contained in a solution must be estimated from its oxyde, or some fixed combination as a chloride (muriate) sulphate, carbonate, &c. and which may be seen by referring to the scale of chemical equivalents. If this should not be sufficiently satisfactory, the process of reduction (exposing the different oxydes to a sufficient heat in a charcoal crucible,) will give the substance in the metallic form.

Chemical reagents, or tests, are either acids, alkalies, and their combinations with each other, or with the different metals; a list of

which for mineralogical chemistry is given on purpose, and their use, as before stated, is to produce such an alteration of colour, &c. as is evident to the senses, and which we know from experience to be the results of certain combinations, or to throw down the substance contained in a solid state, which can be thus collected, and its nature and weight estimated, for example, if an alloy of silver and copper, as in the piece of coin just mentioned, be dissolved in pure nitric acid, and a solution of caustic or carbonate of ammonia be added in excess, the fluid will be changed to a fine blue colour, and which, while some of the former is thrown down in a solid state, also shews the presence of the latter; so far ascertained by testing, we proceed in such a manner as will precipitate the whole of the one without any of the other; if therefore a solution of common salt be added in the most minute quantity, an abundant white flocculent precipitate will fall, which is also known to be silver in combination with the muriatic acid of the salt; 100 parts of which when perfectly dry, I find by the scale, are equal to 75 of metallic silver. If after this a piece of iron

or zinc is immersed, the copper will be obtained in the metallic state; but if either of these metals had been applied at first, both the silver and copper would have fallen together. Should a solution of silver be made from any of the ores of this metal, instead of the alloy just mentioned, the precipitate by ammonia may be brown instead of blue, this will probably arise from its containing iron; and its presence in the solution may be known by its giving a black precipitate with tincture of galls, or a blue one with ferrocyanate of potassa. In this manner we must proceed to test any solution, of any substance presented to us, (see also Test Tube,) and if the first, second, or even third test does not give any indication of its component parts, it ought not to discourage, as we must be so much the nearer, having the fewer remaining to try with, and which must be ascertained by the succeeding ones, unless some substance with which we are at present unacquainted, and for which, therefore, we may not have the test, should be under examination.

The amateur chemist, besides his tests, which ought to be of the utmost purity,

requires certain apparatus which also if well made, are much better than those make shifts occasionally adopted, but which generally cost the operator in a short time much more than the price charged for those of good workmanship, leaving out of the question the pleasure attending their use when compared with the former.

An argument is often adduced against the general adoption of practical chemistry, viz. the expense incurred by such an outfit of apparatus, &c. as is necessary for the pursuit of the science; thus placing it beyond the means of other than persons of considerable property: and this will be readily admitted, if an individual wishes to undertake the whole range to which chemistry is applicable, but which is almost as much beyond his reach, by the time it would occupy, as by any deficiency in his finances. This assertion, however, does not hold good if a branch only is studied, and by the successful and persevering pursuit of which much more real knowledge will be attained, than by a cursory and theoretical idea of the whole; if this is granted, the chief fault will lie in the versatile

spirit of many of those who study it, rather than the expense actually necessary.

It is generally found to be the case, that those things which are of the greatest use, and such as are necessary for our wants in life, are by far the cheapest compared with those of less value and minor utility. This position also holds good with respect to experimental chemistry; to produce one experiment on a decent scale in electricity or galvanism costs as much in the onset as the analysis of half the minerals with which we are acquainted; and no one will dispute on which side the greatest utility lies. A chest containing the following instruments in addition to the tests, (a list of which is given,) will be sufficient in a mineralogical point of view for almost any analysis that may be required.

A balance, or pair of small scales, with an extra short pair for ascertaining specific gravities, (see plate, figure 2) it should be made accurate, at least true to the one-fiftieth of a grain when loaded with 50 grains on each side; this and the weights which accompany it are absolutely necessary in every assay and

analysis, and are used for determining the quantity of matter acted upon or collected. For the method of taking specific gravities see page 68.

The *Point* and *File* for ascertaining the colour of the streak together with the comparative hardness of the specimen, and by which some idea may be in general formed of its nature, quality, &c., the hardest substance known being the diamond, and the softest clay or chalk.

The *Blow-pipe.*—This instrument is composed of a tube having two orifices, a larger and a smaller, and is used to force a stream of air supplied from the lungs through the flame of a lamp or candle, by which means the heat is so concentrated at the focus or extremity of the flame as to enable us to fuse small portions of substances hardly to be acted upon by the long continued heat of the largest furnace. Blow-pipes are made of different materials, such as glass, silver, and brass; the latter is generally preferred, and should be furnished with an ivory mouth-piece and an extra jet or two of different fineness according to the size of the flame required; also a bulb

or cistern near the centre, to condense the moisture which accompanies the breath and which, if not retained in this manner, is apt to collect at the smaller end and extinguish the flame. Some little address is necessary in the use of the blow-pipe, which however is easily acquired:—for an extended use of this instrument, and a minute account of its action on the oxydes of the various metals, &c., see Berzelius on the Blow-pipe, as translated by Mr. Children.

Supports.—Blow-pipe supports are used for sustaining the substance to be acted upon, and are made either of charcoal or platina; the latter in the form of foil, wire, and spoon. The former is generally used where the reduction of a substance to the metallic state is required; and the latter when it is to be collected in the form of an oxyde.

The charcoal used in experiments with the blow-pipe should be produced from light woods, and its goodness is ascertained by its not cracking or scintilating in the fire. When used, a small cavity should be cut with the point of a knife, and the portion to be assayed either alone or mixed up with a flux inserted

in it. The extremity of the inner blue or reducing flame, being now directed against it will very soon produce a globule of metal, if such has been contained in the specimen.

The Platina Spoon is often used, and when neither a very intense heat nor the reduction of a metal is required, it may answer sufficiently well, but as an extended surface always carries off the heat, and the particles are very apt from its shape to fly about, the practical mineralogist often objects to its use: the best modification of this instrument is the spoon forceps.

Platina foil, on account of its extreme thinness is not subject to the same objection as the spoon; when used, a slip about two inches long by half an inch broad is to be taken, and the substance enclosed at one extremity. This metal being a very bad conducter of heat may be safely held at the other end without risk of burning the fingers.

The Platina Wire is to be moistened at the curved end, and dipped into the powdered flux; a portion will by this means adhere to it, which is afterwards fixed by the action of the blow-pipe; the assay is now to be moistened

to make adhere and the whole fused together. Platina, in whatever shape, is objectionable where reduction of an oxyde to the metallic state is required, as the support alloys with the assay at the moment of fusion.

Glass Tube.—When a particle of any ore is to be treated by means of the blow-pipe to ascertain its mineralizer, or what volatile substance is combined with it, such as sulphur, arsenic, &c., it is effected by the glass tube, and which is either closed at one end or otherwise, as the presence of a current of air is or is not required; the vapours will condense on the surrounding parts and may thus be removed and their nature known.

The *Magnet* is used either before or after the action of the blow-pipe; it ascertains by attraction whether iron in the metallic state is contained in the ore, and as every facility should be afforded the tyro, this instrument should not be left out; the best form is that of a needle moving on a fine pivot placed under its centre.

Pestle and *Mortar* for the processes of crushing, pounding, trituration, and levigation.—Every substance intended to be ana-

lysed, requires first to be as finely divided as possible; where valuable, as gems of various kinds, the steel crushing mortar is required, it is used by striking the top of the pestle with a hammer, the substance being previously put n the inside, by this method not a particle is lost; where the quantity is large, an iron mortar, holding about one pint and turned smooth on the inside, with hardened steel pestle should be used; and this, on account of its size, may be kept separate from the chest. When the substance to be pounded is soft the biscuit or porcelain mortar may be used, and for very delicate experiments the agate one is required.

The *Flask*, is used to digest the ore after levigation, in acids or other menstrua, either with or without the assistance of the lamp; it is supported by the brass stand with sliding rings, as in plate, figure 3, which latter is requisite for the different processes of solution, digestion, evaporation, and desiccation; for the latter of which the sand bath and capsule are employed. The stand is also of use to support a funnel for the purpose of filtration after solution, as also for small experiments

on distillation by the retort and receiver, but which are not generally used in the analysis of mineral substances: a mattress is a similar vessel to the flask, having a flat bottom and is used for the same processes, but being made thick requires to be placed in a sand bath when heat is to be applied.

The *Test Tube*, is a small cylindrical glass vessel, and of these there should be at least half a dozen as they are often broken; they are made by cutting off three or four inches of glass tube of the required size and thickness and closing them at one end by the blowpipe; their use is to make assays, by subjecting small portions of the clear filtered solutions to the action of the different tests, in order to ascertain the nature of the substance contained. The closed end should be well annealed as it is often requisite to act upon minute portions of matter in the same manner as with the flask; when, if this were not attended to, the sudden application of heat would infallibly cause their immediate destruction.

The *Glass Plate*, for delicate experiments;

where the quantity of assay is very minute a piece of plate glass is used to test upon; the object in this case being to test with as small a quantity of the solution as possible; to use it, trace a line with a glass or enamel rod dipped into the solution, and with another rod previously dipped into a test, draw a second line across the first, a discolouration or cloudiness will ensue if the right test has been used; if this has not been the case, other tests must be applied and which may be done across the same line, care being taken not to come in contact with the first test; in this manner a single drop is sufficient to enable us to ascertain the nature of the substance contained.

Test tube holder.—This is an instrument which answers the purpose of holding the test tube while one end is over the flame of a lamp.

Watch glasses are used in the same manner as the evaporating dish or capsule, only for smaller quantities; as long as any fluid is contained in them they will bear the heat of the lamp sufficiently well without cracking; their weight should be taken and scratched on

the outside—on weighing again after the evaporation of the fluid the increase will show the quantity contained.

Metallic bars.—A set of these should be at hand, they are equivalent to so many tests, and are chiefly used for precipitating metals in their metallic state.—See Tests, enumeration of.

Matches.—A bundle of these dipped into a composition of chlorate (oximuriate) of potassa and sugar are very handy for immediately lighting the lamp; they may be set on fire by touching the stopper of the sulphuric acid bottle contained in the chest.

Glass rods.—For stirring acid solutions.

Test papers.—Litmus and turmeric papers are used to discover minute portions of either acid or alkali not in combination; acids turning the blue to red, and alkalies the yellow to brown.

Scale of chemical equivalents, for ascertaining the composition of various precipitates, salts, &c.—This table in many instances saves the trouble of reduction; for instance, if we precipitate a solution of lead by sulphate of soda, the sulphate of lead which falls is found

by the table to consist of lead 68, sulphuric acid 32; that invented by Dr. Wollaston is perhaps the best for the student, as it may be at once understood without further trouble or reference.

These, with a few solution glasses, which may be supplied by the use of so many tumblers, are all the instruments that are necessary for the assay or analysis of such minerals as are readily acted upon by acids; but where this is not the case as in those which are intimately united with silicious or stony matter, two more instruments and two extra bottles of alkali furnish the sum total. The instruments are a silver crucible and a small portable furnace; the latter of which may, although not conveniently, be supplied by the use of a common grate, as the heat required for fluxing does not exceed a low red, provided a sufficient quantity of alkali is used; if at any time the heat is increased much above this, the crucible will be run down, and the whole go into the ash pit.

The alkalies are potassa and soda.

LIST OF TESTS.

Besides the instruments already mentioned, the following tests, in a perfectly pure state, should be ready for use; they should be kept in stopped bottles, and the acids should have glass caps.

TESTS CONTAINED IN A CHEST FOR THE ANALYSIS OF METALLIC SUBSTANCES ONLY.

Pure nitric acid
—— sulphuric ditto
—— muriatic ditto
} General solvents

Caustic potassa
Carbonated ditto
Ammonia
Mur. Ammonia
Proto sulphate of iron
Muriate of soda
Prussiate of mercury
} Precipitants.—The last also is a test for copper

Polished bars of iron
——————— zinc
——————— tin
——————— copper
Muriate of gold
Sulphate of soda
Hydro sulphuret of ammonia
Test papers
Nitrate of lead
Prussiate of potassa
Tincture of galls
Oxalate of ammonia
Fluxes

Tests necessary for the Analysis of Mineral Waters in general.

The three acids before enumerated in a perfectly pure state.
The same diluted with three times their weight of distilled water.
Solutions of the three alkalies, potassa, soda, and ammonia.
The same in a carbonated state.
Solution of oxalic acid.
oxalate of ammonia.

Solution of barya.
——— acetate of ditto.
——— sulphate of silver.
——— phosphate of soda.
Alcohol.
Tincture of galls.
——— iodine.
Solution of soap in alcohol.
——— hydro sulphuret of ammonia.
——— prussiate of potassa.
——— nitrate of silver.
——— muriate of lime.
——— hydriodate of potassa.
Black flux.
Test papers
Sulphate of lime.
Nitrate of Ammonia.
Phosphorus.
Silver and gold leaf.

In the analysis of mineral waters a few more instruments, and of larger capacity, are required, as well as extra tests; but the additions are few in number, and not expensive. The reader will observe, that the chest in the plate has an outer case, with side partitions,

for holding acid bottles, with glass caps; by the addition of which larger quantities of these indispensibles can be annexed, and at the same time it prevents any accident which may happen defacing the brass work, chest, &c.; it also preserves unchanged the colour of the litmus paper; otherwise easily affected.

The following are the remainder of the tests used in chemical analysis; many of them may appear duplicates of others, as, for instance, the acetate, muriate, and nitrate of barytes, but they are all necessary in accurate analysis; but where this is not required, one may suffice. To illustrate this by example, we suppose that an ore of silver contains sulphuric acid, and that we wish to separate this before the silver, we cannot use the muriate of barytes, as although it would separate the acid in the same manner as the acetate or nitrate, it would also precipitate the silver; and this shows the necessity of considering what effect the solvent as well as the base used in the preparation of the test will have upon the other substances contained in the solution to be examined.

Tincture of Litmus.

This test, which is of a fine blue colour, is instantly changed to a red by any acid; if therefore any free acid should exist in a solution, it will be thus indicated, although it may not be perceptible to the tongue. Litmus paper is prepared by dipping unsized paper into it, and drying in a dark place; carbonic acid is distinguished from the other acids by its turning the paper red, which changes in a short time to blue again.

Litmus paper reddened by vinegar.

Neither tincture of litmus, or litmus paper, are of themselves good tests for alkalies; but if its natural blue colour is destroyed by slightly acidifying it with acetic acid, it then readily shows their presence by its original colour being restored.

Tincture of red cabbage.

This tincture is a very delicate test both for acids and alkalies, with the former its blue

tint is changed to red, and by the latter to green.

Tincture of Brazil wood.

This test, which is of a red colour, changes to a violet by the introduction of an alkali,

Tincture of turmeric.

Another test for detecting an alkali in solution, and by which its yellow colour is immediately changed to a brown. Paper dipped into the tincture, and called turmeric paper, is frequently so delicate a test as to indicate the soda contained in saliva. Ammonia may be distinguished from either potassa or soda, in the same way as the carbonic is from the other acids, viz.:—by the change of colour produced not being permanent, but flying off on exposure to a gentle warmth, and the original colour being restored.

These tinctures, form the basis of several experiments, and are then used by pouring a quantity sufficient to produce a lively colour into a tumbler, or what is better, a tall glass

jar, which is afterwards nearly filled with water, if now a few drops of acid or alkali are added, and the mixture stirred with a glass rod, the changes above enumerated will take place.

Tincture of galls.

Tincture of galls is used for detecting the presence of iron in solution, with which it forms a black precipitate of gallate of iron; to make the experiment pour a few drops of the test into any mineral chalybeate water, or dissolve a few grains of the sulphate of iron, commonly called copperas, in water, the effect will be immediately rendered evident.

Lime water.

This test readily indicates the presence of free carbonic acid in native or artificial mineral waters, it is also a test for ascertaining the presence of corrosive sublimate; in the first instance a carbonate of lime, a white powder soluble with effervescence in distilled vinegar, muriatic or nitric acids, and

precipitable with, sulphate of soda or oxalate of ammonia is formed; and in the second an orange yellow precipitate: as lime water is a test for carbonic acid, so consequently is carbonic acid for lime; and this is readily exemplified by blowing through a glass tube into a tumbler of clear lime water, the carbonic acid given off from the lungs will soon produce a milkiness in the water, which is owing to the precipitation of the lime in the form of a carbonate; if more carbonic acid was now forced in, the precipitate would be redissolved, and would then be in the same state, viz.:—a bicarbonate, as in most of the pump-water employed for domestic purposes; only that in this latter, there are generally sulphates, and often muriates also contained.

Acetate of silver.

Both the acetate and nitrate of silver are excellent tests for muriatic acid; in whatever state combined, a drop of either when put into a glass of water containing a single grain of common salt, producing a very evident

clouding owing to the insolubility of the muriate of silver thus formed.

Nitrate of mercury.

The solution of this salt is often used to detect chromic acid when in combination with potassa, soda, &c., and with which it forms a deep red precipitate. Also, to separate the arsenic acid often contained in solutions, after the digestion of various ores.

Subnitrate of mercury.

This reagent is sometimes used as a test for phosphoric acid, with which it produces an insoluble white precipitate for uncombined ammonia, letting fall when added to it, an ash grey powder, and for muriatic acid, which it will detect when mixed with 300,000 parts of water.

Oximuriate (per choride) of mercury.

This is used as a test for alkalies, with which, when caustic and fixed, it gives a yellow pre-

cipitate, also with lime, as just mentioned, an orange yellow; but it is chiefly valued as a test for albumen, with a very dilute solution of which it produces a very considerable precipitate. This may be tried experimentally by stirring into a glass of water the smallest quantity of white of egg, afterwards adding a few drops of the test.

Tartareous acid.

The acid of tartar, or tartareous acid, is used to discriminate between the solutions of potassa and soda; with the former it produces, when added in excess, a very insoluble granular precipitate of supertartrate of potassa, often called cream of tartar; but with soda, a very soluble salt: for example, mix in a glass vessel, one part of potassa with 5 or 6 of water, do the same with soda, and then add a sufficient quantity of a concentrated solution of tartareous acid until the previously alkaline solutions exhibit acid properties either by the taste or litmus paper; the granular salt just mentioned, will have been formed in the one but not in the other.

Boracic acid.

Boracic acid is used as a flux for the blow-pipe, particularly on the platina wire; it should be perfectly colourless and transparent, and then indicates by its change of tint with the different oxydes, the metals to which they belong, also for dislodging all the other mineral acids, the phosphoric excepted, and the detection of minute quantities of alkalies in mineral substances.

Acetic acid.

Acetic acid is very generally used in vegetable analysis, to separate resin from gluten; by its action they are both dissolved; but the former is readily precipitated by dilution with water, whilst the latter remains in solution.

Superacetate of lead.

The superacetate of lead, commonly called from its sweet taste, sugar of lead, but which is poisonous, is often used as a test for muriatic

and phosphoric acids; but principally for sulphuretted hydrogen, with which it forms a deep brown precipitate, the hydro sulphuret of lead.

Subacetate of lead.

This test is generally applied for detecting animal mucous, and distinguishing between this substance and gelatin, as also for the separation of extractive colouring matter; as, for instance, if we wish to ascertain the quantity of alcohol existing in port, or other wine. A solution of superacetate of lead is first added to precipitate the colouring matter, after which a little dry subcarbonate of potassa (purified pearl ash) will separate the water; and if the experiment has been made in a graduated glass tube, the percentage of alcohol may be at once read off.

Nitrate of Cobalt.

A concentrated solution of this salt is used in blow-pipe assays to discover the presence of alumina; if a piece of pipe-clay, or other aluminous compound is moistened with a few

drops of the test, and the flame of the blow-pipe afterwards directed on it, a deep blue spot will be made; if, on the contrary, a piece of lime, chalk, magnesia, &c. is tried in a similar manner, no blue tint will be perceptible. Nitrate of cobals mixed with a little common salt, produces a sympathetic ink; characters drawn with it are only visible when the paper is warmed, disappearing again when cold, and in this manner may be made to appear and disappear at pleasure; this is called the green sympathetic ink.

Arsenious acid.

A solution of the white oxyde of arsenic, or arsenious acid is occasionally used as a test for sulphuretted hydrogen, and hydro sulphurets generally; producing with the former a bright yellow precipitate of sulphuret of arsenic, or orpiment.

Muriate of platina.

This test is applied to indicate the presence of potassa, or it salts, when in solution; as also

to discriminate between the salts with base of potassa and those of soda; with the former a yellow precipitate, (the muriate of platina,) and potassa will be formed; but with soda no such appearance will be produced. The solution of platina for this purpose should be somewhat concentrated, and carefully prepared.

Sulphate of copper.

The solution of this salt has been recommended as a test for arsenic, with which it produces, after the previous addition to the liquid of a little carbonated alkali, a green precipitate, the arseniate of copper.

Sulphate of copper and ammonia.

This is another test for arsenic, with which it produces a pea-green precipitate; and which, when dried, and placed on a piece of ignited charcoal, produces the peculiar garlic odour characteristic of the metal.

Solution of sulphuretted hydrogen.

This test is generally employed for the precipitation of most metallic bodies, throwing down nearly the whole of them from their solutions in the form of hydro-sulphurets; the nature of which is often readily ascertained by the colour, and for which see the table further on.

Sulphuretted hydrogen is soluble in water; but the solution is again very soon decomposed with precipitation of the sulphur. It is an excellent test for lead when contained in wines.

Solution of carbonic acid.

A test for lead and lime, as already mentioned.

Benzoate of ammonia.

This test is used in the separation of the oxyde of iron from that of manganese; for example, suppose a solution of the latter, con-

taining the former, as is the case after digesting the common ore of manganese in sulphuric or muriatic acids, the liquor is to be rendered exactly neutral by the addition of ammonia; the present test now dropped in until no further precipitation takes place, will remove the whole of the iron in the form of a benzoate; whilst that of manganese will remain in solution. Caustic ammonia will also answer the same purpose.

Subborate of soda.

Common borax, or subborate of soda, is one of the best fluxes for the blow-pipe; it should be dried, or fused into a glass, and afterwards reduced to fine powder; it is also used in the analysis of argillaceous stones.

Glass of phosphorus

This is also another flux often used in blow-pipe assays; it should be made from the pure phosphorus, and not from the desiccation and subsequent fusion of the impure phosphoric acid, as obtained by the action of sulphuric

acid upon bone ash, as is commonly done, and which always contains a large portion of sulphate of lime.

Proto muriate of tin.

This is a delicate test for platinum and gold; producing with the first a yellow precipitate, and with the latter a purple, commonly called the purple precipitate of cassius, and used in enamel painting, glass staining, &c.

Muriate and nitrate of barytes

These are both used in analysis, together with the acetate and barytic water, to discover the presence and quantity of sulphuric acid contained in any solution. It is, therefore, an excellent test for ascertaining the purity of lemon juice, which is sometimes sharpened by this acid.

Muriate of alumina.

Muriate of alumina is used as a test for carbonate of magnesia in mineral waters; this

latter substance not being wholly separated like carbonate of lime, by boiling the water; muriate of alumina dropped into the water, after ebulition, will precipitate carbonate of alumina, if carbonate of magnesia is present; but not otherwise, unless there should be an excess of alkali, which is to be previously neutralized bya weak acid.

Succinate of ammonia

Produces with the solutions of peroxide of iron a brown precipitate soluble in excess of the test, which is, therefore, to be avoided. It is also used for the same purpose as the benzoate of ammonia.

Prussiate of potash.

This test, also called ferro prussiate and ferro cyanate of potassa, and which terms the reader will find, perhaps, indiscriminately used in the following pages, is one of the most generally useful in the list of chemical reagents: forming precipitates in all the solutions excepting those of gold, antimony, tellu-

rium, platina, iridium, rhodium, and osmium: and from the different colours of these precipitates a correct idea may be generally formed of one of the constituent parts of a solution. For its action on the different metallic solutions, see the table.

Prussiate of potash is often used as a sympathetic ink; but in this instance another reagent is also necessary, viz.:—the nitrate or muriate of iron; when, therefore, the one party corresponds in characters drawn with the solution of prussiate of potash, the other has only to draw over the sheet a sponge dipped in a solution of nitrate of iron, when the characters immediately assume a fine blue colour, which is owing to the formation of Prussian blue; in return the other party writes with the iron liquor, which is afterwards rubbed over with the solution of prussiate of potash.

Prussiate of ammonia.

This test is chiefly used in the analysis of saline substances, when in combination with metallic salts; it being of advantage in this

case not to introduce any extra quantity of salt, as would happen if the prussiate of potash was used. In general the tests with an ammoniacal base are preferable to the others, as the latter is easily separated afterwards by heat, which cannot be effected with potassa or soda.

Prussiate of mercury.

This is chiefly used as a precipitant for palladium, which it throws down in the form of a yellow powder, the prussiate of the metal; and which is possessed of fulminating properties when its temperature is raised much above the boiling point of water.

Solution of starch.

A solution of starch in water is an excellent test for free iodine in solution; the test is said to be effective to the one fifty thousanth part; the mixture assumes a fine blue tint, and a powder of the same colour is afterwards precipitated, which is the ioduret of starch.

Should the iodine be in a combined state as in the hydriodate of potassa, it will be necessary to add a small quantity of acid to liberate it; the test will not otherwise be effective.

Fluate of ammonia.

This is occasionally used as a test for lime.

Tan.

The solution of tan is used to detect animal gelatin or jelly; thus if a solution of glue is added in a very small proportion to a quantity of water, and this test is dropped in, an immediate precipitation takes place, and which, when collected and dried in the air, becomes hard and brittle, with a resinous appearance. Tan also precipitates albumen, but not so immediately as in the other case. Oximuriate of mercury, the test for albumen, does not precipitate gelatin; the difference, therefore, is too apparent to occasion any error.

Quicksilver and silver leaf.

These metallic substances are also occasionally used as tests to discover the presence of very minute portions of sulphuretted hydrogen in mineral waters, which they indicate by the tarnished appearance they assume, by immersion in the water for a few hours.

Gold leaf.

This substance is used in the analysis of mineral waters to detect the presence of nitric acid, sometimes, although but rarely contained; the action of the test is founded upon the well known fact that no menstrua, the solution of chlorine and nitric and chromic acids, when united to the muriatic acid excepted, will produce any effect in dissolving gold; if therefore, a mineral water is suspected to contain nitric acid, nothing further is necessary to prove it than to add a few drops of muriatic acid to it and boiling with a strip of gold leaf; if any of this metal has been dissolved, as will readily appear by testing

with the protomuriate of tin, its presence is pretty clearly ascertained.

For the action of the remainder of the tests, the reader may refer to the table page. In the preceding enumeration of the action of the different tests, a few examples only have been given, the remainder may, however, be tried in precisely the same manner.

ENUMERATION

Of those processes, some of which are always necessary in the chemical examination of mineral substances.

Pulverization or reduction to the state of powder. This is effected by breaking down the substance in a mortar with a pestle until it has acquired the sufficient degree of fineness.

Trituration differs from pulverization only in degree; it is effected by giving to the pestle a rotary motion.

Levigation is performed in the same manner as trituration; only that as in this case an extremely fine powder is required, a small quantity of some liquid, generally water, is used to keep down the fine particles which would otherwise be blown away.

Digestion is the means adopted for obtaining a solution; and the apparatus used is either the mattrass or the flask. The digestion of any substance is finished, when on the addition

of a fresh portion of the solvent no further action takes place, or the whole is taken up. Digestion is sometimes performed in a retort when it is an object to collect any volatile substance, or to save the fluid, as in abstraction.

Filtration, (for the separation of suspended or undissolved matter.) Solutions to be tested should always be perfectly clear and transparent, otherwise the precipitate produced by the action of a test will be mixed with the undissolved matter of the previous process; for this purpose, various substances are used, such as sand, asbestos, linen, paper, and twisted cotton. The two first are seldom used in analysis, and are only applicable where it is necessary to filter very acid solutions or considerable quantities of any fluid; for instance, when we wish to clear sulphuric acid from any substance accidentally dropped into it, sand or pounded glass may be put into a funnel and the acid poured on the top; it will, in a short time drop through, leaving its impurities behind. To make a sand or glass filter, it is necesary first of all to put into the funnel some larger pieces, to

prevent the remainder falling through. The whole of Paris is supplied with water filtered on a large scale, but by means similar to this. Asbestos may be used for small quantities of acid; but unless very fine, which is not always to be got, it makes but a poor filter. Linen is used for collecting precipitates, and for the process of straining, which differs from filtration only in degree; when any great nicety is not required, linen will often answer the purpose sufficiently well; and as it occupies less time than the following, it is often adopted; a square of it should be fastened by tacks to the inside of a filtering frame, and may be used either single, double, or lined with sheets of paper. The paper filter is, however, generally used in the processes of analysis; the description employed for filtration is without size, and should contain as little colouring matter as possible; when used, a square piece in proportion to the size of the funnel, is to be folded into a triangular shape, and again doubled; this will give two cones, which are to be placed in the funnel in an inverted direction; one of these are to be opened, and the liquid to be filtered gradually poured in.

If the solution is corrosive, it will be necessary to have a double filter, or what is often as well, a small cap made in a similar way to the former, and slipped over the point of the larger.

It generally happens in filtering that the first portions which come through are opaque and milky; these are to be returned and filtered again, when they will pass through clear. Filtration does not remove the colour from a fluid unless that arises from suspended and not dissolved matter. The twisted cotton is occasionally used when the object is to separate one fluid from another; for instance, oil from water; to effect this one end of a moderate sized cotton wick is introduced into the liquid, while the other hangs over the side of the vessel, close to which a second is placed to collect the drops that fall: the effect is produced by capillary attraction.

Precipitation is directly the reverse of solution, and consists in the separation of a body from its solvent. The substance which falls is called a precipitate; and is in the state of a finely divided powder differing in degree ac-

cording to the state of dilution of the liquid employed.

Decantation is often used instead of filtration for fining solutions; and where it can be done quickly it is the best method of the two. A decanting vessel is a tall glass with a broad bottom; and when any liquid is to be decanted, it is first put into it, and after the fluid has become clear by subsidence, poured off again; the grosser particles remaining behind. Fresh water being now poured upon the dregs, and again decanted will remove every portion of the fluid, without the loss arising by evaporation, absorption by the filter, &c.

Elutriation.—By this term is meant the repeated washing of any substance, (as a precipitate) to free it entirely from its former solvent; in analysis these washings must be added to the remaining filtered solution, as probably still containing some matter, although not of the same kind as that precipitated; for example, in the examination of a solution of an alloy of copper and lead, the latter would be precipitated by sulphate of soda; but, if the washings of the precipitated

lead were not collected, and added to the remaining solution, a considerable portion of the copper would be lost; if on the contrary, the precipitated sulphate of lead is elutriated until, upon a portion of the washings being tested with ammonia in excess, no blue colour is afforded, we are sure no particle will escape our vigilance. The immersion now of a bar of iron, will throw down the whole of the copper contained.

Perfect elutriation is thus shown to be absolutely necessary in analysis, and must be continued until the last washings come away tasteless, or until they give no indication if a test is applied. This process is also useful for separating the light from the heavy particles of matter, as in sweep washing, gold sand washing, &c., which is effected by a continued stream of water and constant agitation in a vessel of the proper shape; by this means the lighter particles of sand are recovered from the gold dust which, on account of its great specific gravity remains at the bottom.

Evaporation is a chemical process, and *is* used to separate the volatile from the fixed part of any solution or compound body; for

example, if we wish to assay an amalgam of gold and mercury, the heat to which it is to be subjected, will drive off the mercury, while the gold will remain; in this case the quicksilver was volatilized or evaporated. Evaporations is, however, more properly applied to the expulsion of aqueous particles, as in the evaporation of brine springs for the produce of common salt—the concentration of syrup, to form crystals or sugar candy, &c. &c. In short no process is oftener required in chemistry than evaporation; and in analysis it is used either for concentrating solutions, particularly the washings to a convenient bulk, or to obtain the quantities of solid matter contained in any fluid as in desiccation; it is also the acting principle in distillation. Evaporation is much facilitated by an extended surface, with a good current of dry air, and by continued stirring or agitation. A very good and simple method of effecting this mechanical action for evaporating solutions I have found in the employment of a domestic article, the common bottle jack; if this machine is selected with a strong spring, and instead of the chain usually attached, two or four straight

wires ending with slips of wood or glass tubes are fastened, by drilling holes at equal distances in the wheel, a vertical motion is obtained equal to the employment of a pair of hands, providing that the fluid does not require to be stirred from the bottom; to effect which, a much greater force will be required than is, I believe, to be obtained by this instrument.

One of the best modes of evaporation is by steam, as in the absence of the operator no mischief arises from want of stirring, which in other cases would often spoil the preparation by burning, particularly if a gummy or extractive matter. A small steam bath is attached to the lamp furnace; which is very useful for drying precipitates, or fulminating compounds, as the heat never rises above 212, and may be regulated to any degree we may think proper. Evaporation in vacuo, is a recent improvement, and is of considerable utility in the distillation of ardent spirits—in the preparation of various pharmaceutical preparations, and in all cases where evaporation is required at the lowest possible degree of heat. The instrument used in analysis for

evaporating, is called the evaporating dish or capsule, and is made either of porcelain, glass, silver, or platina.

Distillation is only another form of evaporation; but the object in this case, is to condense and collect the vapour which rises. The instruments used for distilling, are either the retort and receiver, and the alembic and capital, or in the large way, the still and worm tub; retorts should be blown as thin and light as possible, especially in that part where the heat is to be applied: by distillation, another, and often important end is gained, viz. the separation of colouring matter; if we take a portion of brandy and distil it, we shall obtain the spirit and the water, while the colouring matter will be left in the retort; and this is the best method of ascertaining the real percentage of alcohol contained, as if again put into the retort with a little dry muriate of lime, the spirit only will be driven over. A shorter method of ascertaining the quantity of alcohol in any fluid, is by the hydrometer, which, however is liable to deception; where a true and quick method is required, the spirit after its first distillation, may be poured into a

tube graduated to 120 degrees, furnished with a foot and stopper, until it reaches up to 100 degrees, and add dry salt of tartar or muriate of lime, which will cause a separation of the water, and the quantity of alcohol which separates, may be at once read off; thus, if 100 degrees of the spirit are by this means changed into 60, the fluid contains 60 per cent. of real alcohol; if into 40, 40 per cent. and so on; the reason of the number of divisions exceeding 100, is to allow a small increase of bulk, which will take place on the addition of the potassa, or muriate of lime: in this way the strength of the different wines, spirits, ales, &c., may be accurately determined. First get rid of the colouring and extractive matter, by subacetate of lead, and afterwards of the water, as before mentioned. In distilling by the retort and receiver, the heat should be applied gradually, otherwise a risk of breakage will be the consequence.

Abstraction is a repetition of the process of distillation, as in the solution of difficultly soluble matter, where repeated portions of fresh acid, &c., are necessary; also in the preparation of essential oils, in which process the

water is returned on the plant several times, to effect the ascension of the oily particles with the least possible loss; which could not be avoided if successive quantities of fresh water were employed, as each portion holds a certain quantity in solution which cannot be separated, and which is therefore lost.

Reduction is generally effected in crucibles, vessels made of baked clay, and sand, porcelain, or black lead, (carburet of iron) the object is to reduce oxydes to the metallic state, by the action of heat, and some substance intermixed, which has a stronger affinity for the oxigen than the metal itself; thus if the oxydes of lead, litharge, red or brown lead, are subjected to heat, little change takes place; but if they are first mixed with charcoal powder, the metal will be revived, the oxigen uniting with the carbon, and passing off in the form of carbonic oxyde.

The reduction of metals from their oxydes, is one of the best methods for obtaining them in a pure state: if, for example, we wish to prepare the article called gold powder, or shell gold for the artist, and neglect using mercury which has been received from the oxide, the

colour will not be so good as when this precaution is taken; notwithstanding we may have previously distilled what is vended by the dealer in the first instance as pure.

Roasting is the first process (after crushing) to be adopted in the treatment of ores in the dry way; it is effected on the small scale by he muffle, which fits into one of the side openings of the portable universal furnace, an instrument in assays not easily dispensed with. The ore is first of all to be broken into small pieces, or reduced to a coarse powder, when it is to be evenly spread on the flat surface or floor of the muffle, when upon the addition of heat the sulphur and arsenic, together with any other volatile substance, will be expelled, and will either collect on the dome or be driven up the chimney, according to whether it is made close, or is furnished with grooves to allow a current of air to pass through. Roasting is absolutely necessary for the generality of ores in the large way, as if smelted directly the metal, although obtained, would be brittle and totally unfit for the manufacturer's use. The heat employed, should always be very moderate at first, and continued

until the vapours entirely disappear. No rule can be given as to the time, some requiring more and others less, according to the quantity of the mineralizer contained, and the tenacity with which it is retained by the metal. Roasting is generally performed on the large scale, by placing alternate layers of ore, broken into small pieces, and of coal or turf, igniting the pile at the bottom, and continuing the combustion for days and weeks together: the more fusible metals are often reduced in this manner, and the fused metal is collected in a pit dug for the purpose underneath.

Cupellation is applicable only to gold and silver; it is performed by alloying these metals, when in an impure state, with two or three times their weight of lead, placing the alloy on a cupel or support made of bone ashes, putting this into a muffle and continuing the heat until the gold and silver alone remain; in this case the lead, together with the impurity, the separation of which the cupellation was undertaken, will have sunk into the body of the cupel, from which they may be again obtained if required.

Cupellation will not separate gold from silver or platina; for which see article on Gold.

Vitrification—A substance is said to be vitrified, when it assumes the characteristic properties of glass; thus the oxyde of antimony, when run into a brittle transparent substance, is denominated vitrified, or glass of antimony, perhaps a circumstance of this kind gave rise to the idea of a malleable glass; the oxyde of arsenic will do the same.

Stratification—this term although seldom used, is meant to imply the process of alternately placing layers of different substances, stratum superstratum, on each other, in order that a combination may take place; thus on account of the volatility of zinc it cannot be readily alloyed with copper; the process therefore adopted, is to place alternate strata of calamine or carbonate of zinc and copper; when at a high heat the first metal rises, is combined with the second, and brass is the product.

Granulation, or the mechanical division of a metal is effected in several ways, some of which are better than others, according to the nature of the metal to be granulated; it may

be effected by pouring the fused metal into water, as in the making of shot, by stirring it with an iron rod until it cools, or by agitation in a box, rubbed on the inside with chalk, which may afterwards be washed off. Granulation is frequently adopted to facilitate solution, as also the separation of arsenic and sulphur in the refining of copper.

Fluxing is a chemical process similar to solution, and is used in analysis to act upon silicius or stony matter when so far predominating in a mineral as to impede the action of acids upon it; it is thus performed:—Mix any given quantity of the ore in a minute state of division, with four times its weight of caustic potassa or soda, in a silver crucible; put on the cover and subject to a low red heat for half an hour, or until the mass assumes a pasty or liquid form, remove from the fire, and when a little cooled, pour in hot water; the heat still contained in the mass will occasion an ebullition, when the fluid may be decanted, and more hot water added. Continue the elutriation until the whole is detached, grind down the lumps in a porcelain mortar, with a fresh quantity of hot water as before, and throw the whole upon a filter:

the residue after again washing, will be the mineral divested of its silex and earthy matter, and which if the fluxing has been well performed, will now be entirely soluble in acids; should any however remain after their action, it must be fluxed again as before; for the analysis of alkaline solutions, see Earths and Stones.

Fusion, is the converting of solids into fluids by heat, provided the temperature required is above the medium heat of the surrounding atmosphere, thus lead is fused, but the term is not applicable to water or mercury, although they are both solids changed by heat into fluids. The fusion of a substance is effected by various means, according to the nature and quantity of the matter to be acted upon. In the minute way, the blow-pipe is used; in the larger way the crucible and furnace. In some cases substances are not to be reduced by either of these methods, when recourse must be had to galvanism.

Under the head of fusion, I shall just mention an highly useful and improved modification of the oxyhydrogen blow-pipe, invented by Mr. Goldsworthy Gurney, who has published an account of it, and which merits more

attention among scientific chemists, than it appears to have generally met with. If this instrument is well made and ably worked, which requires very little address, it is competent with perfect safety to the operator, to the fusion of many substances which the strongest furnace will not touch: for instance, platina is immediately run down by it, and volatilizes it in the form of an oxyde, if the heat is continued. The intensity of heat produced by this means, although very great, does not seem equal to that of the galvanic battery on a good scale; but, the expense and trouble is so much less, that it will be found an useful ornament to the laboratory; with respect to the action of the mixed gases on platina, there appears to be wanting some accurate experiments, as a metal infusible in the furnace runs with the facility of silver before the flame of this blowpipe, and this coupled with the late experiments of professor Doberainer, who ascertained the curious fact that platina in a minute state of division will take fire when exposed to a stream of cold hydrogen gas, are too singular not to merit further inquiry; while rhodium, one of the constituents of the platina ore, is

not in the least affected by its agency, although exposed in very minute quantities to its action for a considerable time.

For the purposes of fusion, the portable universal furnace, (as represented in the plate) is an elegant instrument; it is made of strong wrought iron plates fastened together, and lined inside with fire bricks, bedded in loam; the height of this furnace without its chimney, is two feet. The inner diameter of the cylindrical fire-place, measures 12 inches. The body of the furnace is circular; in its upper part a circular hole is cut, for receiving an iron sand-pot which may occasionally be removed, and exchanged for an iron plate. In the front of the furnace there are three openings over each other, furnished with sliding doors, and fitted with stoppers made of crucible-ware. The lower opening is the ash-pit of the furnace; and is furnished with a door which opens and shuts in order to diminish, or enlarge the opening for regulating the heat, by admitting or excluding air at pleasure. In the side of the furnace a hole is cut, furnished with a stopper and door, for passing a tube through

the fire place of the furnace: an expedient essentially necessary for a variety of chemical processes, such as exhibiting the decomposition of water, alcohol, oils, &c., for the preparation of phosphuret of lime, for passing gases over ignited bodies, &c. In either of the openings in front of the furnace, a muffle may be placed for the cupellation of gold, silver, &c., or, the neck of a retort (placed on a stand in the body of the furnace) may be passed through it, for distillation by the naked fire, for procuring gases which require a high degree of heat, &c. If the iron sand-pot be removed, and a circular plate properly lined with fire clay be placed in its room, the furnace becomes converted into a wind-furnace; the fuel is then to be introduced through either of the openings in front. The iron plate at the top has a hole in the centre, furnished with a stopper, to enable the operator to inspect his process at pleasure. If the iron pot be placed inverted on the opening of the furnace, it forms a dome, and the furnace becomes a reverberating furnace. The iron pot when filled with sand, or water, placed in its proper situation, serves as a sand or water bath, for

the processes of distillation by means of glass retorts, for evaporations, sublimations, digestions, &c. Coke and charcoal, are the best fuel: this mixture burns without smoke, and gives a strong uniform and permanent heat: charcoal and common coal, or coal only, does likewise very well. The elbow of the chimney may be directed into that of the fire place of any apartment. The furnace is furnished with castors, and may therefore be easily moved according to the convenience of the operator. The great advantage of this portable universal furnace, above all others I am acquainted with, consists in consuming as little fuel as possible; in producing quickly if required an intense heat; in the power of applying it as directly and as fully as possible to the substance on which it is intended to act; in regulating expeditiously and at pleasure its intensity; in enabling the operator to perform any operation whatever which requires the aid of heat, and moreover in being able to perform these operations in the closet, or in any other place without risk of endangering the conflagration of the surrounding objects which were not meant to be exposed to the action of fire.

In order to fuse a substance in the furnace, it is necessary to inclose it in something which will not run down in the heat applied, otherwise the product will be lost; for this purpose the crucible is used which is made of such materials as are capable of supporting an intense heat without breaking or melting; those which are made of clay and sand should not be used for saline fluxes, these substances acting upon them at a high heat; neither should platina ones contain any oxyde to be reduced to the metallic state, without first lining them with charcoal paste; and those made of silver will not stand more than a low red heat; crucibles, when used should, if made of clay and sand, be first well warmed, and then exposed to a gradual heat placed on a crucible support, or piece of brick, previously set on the grate of the furnace; if this precaution is not taken, the current of cold air will be sure to break them, whilst at the same time part of the pot would be below its heat.

When the fusion of a metallic body is complete, it may be removed from the fire and suffered to cool, when the metal will be found in the shape of a button at the bottom; or it

may be poured out into a mould previously warmed and rubbed with chalk or black lead, to keep the ingot from adhering to the sides.

Crucible moulds are called casting cones and ingots, according to their shape.

In conducting all experiments in analytical chemistry, the use of pen, ink, and paper is highly necessary, as they are as much and as often required as any utensil in a laboratory; for unless every thing is properly labelled, confusion, loss, and disappointment, are sure to result; and when a novel appearance is assumed by any preparation, which would be interesting, and, perhaps, useful to the operator; it is often thrown down the sink for an unknown and useless product. To attain to excellence in any study or pursuit, a certain degree of perseverance and attention are always required. To one person chemical analysis might present obstacles which the active and discriminating judgment of another would pass over as trifles; but the utility of which would be admitted by both.

As disappointments in the beginning are always discouraging, the reader is requested, if unacquainted with chemical subjects, first

of all to try such examples as the following, together with those previously enumerated under the head of tests, as he will in them be able to judge whether he is right or wrong, without the aid of a second person; he is then recommended to try the assays, and afterwards proceed to analysis.

EXAMPLE 1.—Take 24 grains of gold, dissolve it in a sufficient quantity of nitro muriatic acid, rather dilute, and which may be composed of—

1 part muriatic acid,
2 parts nitric ditto,
2 ditto water,

proceed with this according to the rule given in digestion, when finished, filter through paper, (see filtration) elutriate (see elutriation) and precipitate in the metallic form by a bar of zinc, apply a gentle heat to separate the last portions; scrape the bar clean, to recover every particle of gold, collect on a filter, wash and dry; if the process has been well conducted, and the gold fine, it will be regained entire, or at the most at a loss of not more than one-third of a grain. Fine gold, as purchased from the refiner, often contains

silver; if this is the case, a white flocculent precipitate, the chloride of silver, will be left after digestion, it is to be collected, dried, and either estimated as three-fourths silver, or mixed with a little flux, and a drop of water, to the consistence of paste, placed on a coal (piece of charcoal) and reduced to the metallic state with the blow-pipe.

2.—Take a piece of standard gold, dissolve as before, if any chloride of silver appears, it is to be collected; separate the gold by a dilute solution of green sulphate of iron; collect as before, elutriate and insert in the liquid a piece of clean iron. The copper will be precipitated.

3.—To the solution of standard gold, add ammonia in excess, the gold will be precipitated in the form of a fulminating oxyde, while the copper will remain dissolved; saturate the excess of ammonia with dilute sulphuric acid, and immerse a plate of iron, as before.

4.—Take any given weight of fine silver, dissolve in pure dilute nitric acid, with the assistance of the lamp, &c. test a small portion of it with ammonia in excess; if it should turn to a blue colour, it contains copper, as

in fact, most refiners silver does. Precipitate in the metallic state by a piece of copper, the whole of the silver will be thus regained in fine filaments. The only loss of the process, if carefully conducted, being that portion of copper originally contained.

5.—Dissolve a few grains of the silver precipitated in the last process in nitric acid, add to it a solution of common salt or sal ammoniac; a white chloride of silver will fall, 100 parts of which, when dry, indicate 75 of metal; dissolve this precipitate in caustic ammonia, acidulate with nitric acid, and add sulphate of soda in solution, white crystals will fall, which are the sulphate of silver.

Gold, silver, and copper, may be obtained from their solutions in the crystalized metallic form, by immersing in them pieces of clean phosphorus or charcoal; it depends on the circumstance, that whenever a substance, having a strong affinity for oxygen is added to the solution of a metal which has but a slight affinity for it an exchange takes place, and the metal is reduced.

6.—Dissolve a piece of lead in nitric acid; on adding to it a solution of muriate of soda, a

white precipitate is formed insoluble in ammonia, and by which it may be distinguished from the precipitate of silver; chloride of lead is soluble by digestion in excess of nitric acid, which is not the case with chloride of silver.

7.—In a solution of nitrate of lead, suspend a piece of zinc, thin fine crystals of lead in the metallic form, will, in the course of a few hours, shoot out in every direction, constituting what is called the lead tree.

8.—To a solution of metallic lead, white lead, red lead, or litharge, add a solution of sulphate of soda; sulphate of lead will be precipitated, which, when collected and dried, may be estimated by referring to the scale of chemical equivalents, as we find it stated as consisting of 32 oil of vitriol and 68 of lead: if then 102 grains of lead are originally taken, and 150 grains of the sulphate are collected the process will have been well conducted. The sulphate may be decomposed, and metallic lead again obtained by fusion with charcoal, which having a stronger affinity for oxygen than sulphur has, decomposes the sulphuric acid, the

base of which burning off, leaves the lead reduced to the metallic state, 100 grains ought to be collected from 150 of the sulphate. To another portion of the liquid, add chromate of potash, a fine yellow pigment chromate of lead will fall.

9.—Digest a given weight of tin in four or five times its weight of nitric acid rather dilute; a violent action will soon commence, at the same time throwing the whole of the metal down in the form of an oxyde, reduce this oxyde again to the metalic state by fusion with charcoal, if the same quantity of metal is collected as was first employed the process is finished.

10.—Dissolve a piece of block tin in muriatic acid with heat, immerse into the solution a plate of lead, metallic tin will generally fall.

11.—Make a solution of mercury in nitric acid, and immerse a piece of iron, the metal will be thrown down in the form of a dark brown powder, which when collected, dried, and heated in an iron vessel, runs again into fluid mercury. If copper is used, a similar effect is produced.

12.—Mix together seven parts of mercury with one and a half of sulphur, put the mixture into an alembic or flask, place this again in a sand bath, and apply heat; sulphuret of mercury or cinnabar will be produced which, when ground in a mortar, constitutes the fine pigment called vermillion.

13.—Dissolve a known quantity of iron in muriatic acid; precipitate by caustic ammonia; mix this oxyde into a paste with linseed oil, and subject to a strong heat in a crucible, when cold try it with the magnet to ascertain whether it is in the metallic state.

14.—Take a solution similar to the preceding; add to it one of prussiate of potassa until no further deposit is given; the precipitate is pure Prussian blue, or iron united to prussic acid. Add to another portion tincture of galls, a black precipitate will in this case fall, which may be treated like the first; it is a compound of gallic acid and iron.—If the precipitate is suspended by adding gum to the mixture ink is produced.

15.—Take any quantity of white oxyde of arsenic, mix it with half its weight of charcoal

powder, and subject to heat in a subliming pot; metallic arsenic, in a crystallized form, will be the result: care must be taken in this experiment not to inhale any of the fumes which arise.

16.—Take two or three ounces of clear plate or window glass, (vitrified flints,) put them into a clean crucible with ten grains of oxyde of cobalt, and fuse the whole with a good heat for an hour, a fine blue glass will be produced.

In this manner the different artificial gems may be made; the whole of them depending for their colour on the admixture of a metallic oxyde; thus oxyde of chromium produces a fine green; the precipitate of gold by tin, a fine purple; oxyde of iron a yellow; oxyde of tin a milk white; oxyde of manganese a black, and so on.

Distinguishing properties of ores.

Metallic ores are distinguishable from other minerals by their greater specific gravity, being seldom less than four times as great as that of water.

It is only necessary therefore to weigh them hydrostatically, in the following manner, to discriminate between metallic ores and other minerals.

Free a piece of mineral from its matrix; suspend it by a horse-hair or thread of silk from the scale of a fine balance; weigh it in the air, and mark down its weight; then immerse the scale with the mineral still suspended in distilled water, and ascertain how much it loses of its first weight in the air: that is so say, how much weight is necessary to bring the scale to an equilibrium when the substance is suspended in water. Having done this, divide the sum of the weight in the air by the sum of the weight which the body lost during its immersion in the water, and the quotient will shew the specific gravity of the mineral.

EXAMPLE.—Suppose a piece of mineral weighs in air 480 grains, but when in water, it weighs but 400 grains, it will require 80 grains to restore the equilibrium, and the specific gravity will be 6; because 480 divided by 80, gives 6 for the quotient; it therefore is six times heavier than water,

consequently contains some metal, and belongs to that class of minerals called ores.

Note.—This is speaking in a general point of view, as there are many minerals containing a metal in combination with oxigen, and therefore to be classed as ores, whose specific gravity is not above 3; and, in a few cases, less than that.

Description of Veins, Matrix, &c. of Ores.

Ores are almost invariably found in the interior of the mountainous districts of the earth, and very seldom at the surface, or in plain or level parts.

The name of veins has been given to those portions which are met with in the clefts or crevices of rocks; and being always more or less inclined to the horizon, are therefore, called oblique, direct, or inclined veins, according to the angle which they make therewith.—Nature has thus rendered their discovery more easy than if placed in a level or in plains.

Veins are generally either deposited upon or surrounded by a substance of a different

nature from that of which the rock is composed; and this substance, whatever it may be, is called the matrix of the ore.

This, it must be remembered, is not the mineralizing substance with which the metal is combined, such as arsenic, carbon, sulphur, &c.

With these, the metal is chemically united, and cannot be separated but by chemical means.

The matrix, on the contrary, may be removed by mechanical power.

ORDER OF THE METALS.

The following metals have been placed according to their relative non-affinity for oxigen; with perhaps, the exception of the last fourteen, here called Metalloyds, which are, as regards their metallic properties, but little known at present.

Platinum	Selenium
Gold	Cerium
Silver	Titanium
Palladium	Uranium
Rhodium	Cobalt
Iridium	Bismuth
Osmium	Antimony
Mercury	Lead
Nickel	Copper
Columbium	Wodanium
Tungstenum	Cadmium
Chromium	Tin
Molybdenum	Zinc
Arsenic	Iron
Tellurium	Manganese

Metalloyds.

Potassium	Aluminum
Sodium	Zirconium
Lithium	Glucinum
Calcium	Yttrium
Barium	Thorinum
Strontium	Silicium
Magnesium	

Note.—Metalloyds: This is a French term as applied to these substances; it is equivalent to semi-metallic, as, although possessing some properties in common with the metals, they are wanting in many others peculiar to this class of bodies.

Table of the Metals.

Names.	Sp. Gr.	Precipitants.	Colour of Precipitates, by			
			Ferrocyanate of Potassa.	Infusion of Galls.	Hydro Sulphurets.	Sulphur. Hydrogen.
Platinum.....	21.47	Mur. Ammon.				Black
Gold	19.30	Sulph. Iron Nitrate Merc.	Yellowish White	Green Met.	Yellow	Met. Powder Yellow
Silver.....	10.48	Common Salt	White	Yel. brown	Black	Black
Palladium	11.8	Pruss. Merc.	Deep Orange		Blackish brw.	Black brown
Rhodium	10.65	Zinc?				
Iridium	18.68	Ditto				
Osmium.....	?	Mercury		Purple passing to deep blue		
Mercury.....	13.6	Common Salt heat	White passing to yellow	Orange Yellow	Brownish black	Black
Nickel	8.4	Sulph. Potas.	White	Grey White	Black	Black
Columbium	5.6?	Zinc or inf. Galls	Olive	Orange	Chocolate	
Tungstenum	17.4	Mur. Lime?	Dilut. acids			
Chromium	5.90	Nit. Lead	Green	Brown	Green	
Molybdenum	8.6	Ditto	Brown	Deep brown		Brown
Arsenic.....	8.35? 5.76?	Ditto	White		Yellow	Yellow
Selenium	4.3	Iron Sul. Am.				

Table of the Metals. (continued.)

Names.	Sp. Gr.	Precipitants.	Colour of Precipitates, by			
			Ferrocyanate of Potassium.	Infusion of Galls.	Hydro Sulphurets.	Sulphur. Hydrogen.
Tellurium.....	6.115	Water Antimony		Yellow	Blackish	
Cereum.....	?	Oxal. Amm.	Milk white		White	
Titaneum.....	?	Infus. Galls	Grass green	Red brown	Grass green	
Uraneum.....	9.0	Ferrocy. Pot.	Brown red	Chocolate	Brown yellow	
Cobalt.....	8.6	Alk. Carbon.	Brown yellow	Yellow white	Black	
Bismuth.....	9.88	Water	White	Yellow	Brown black	Brown black
Antimony.....	6.70	Water	With dilut.	White from	Orange	Orange
		Zinc	solutis. white	water		
Lead.....	11.35	Sulph. soda	White	While	Black	Black
Copper.....	8.9	Iron	Red brown	Brown	Ditto	Ditto
Wodanium.....	11.47	Zinc	Pearl Grey			
Cadmium.....	8.6	Zinc	White		Orange yel.	Orange yel.
Tin.....	7.29	Corr. Subl.	Ditto		Protox. Black	Black
					Perox. Yellow	
Zinc.....	9	Alk. Carb.	Ditto	Grey white	White	Yellowish Wt.
Iron.....	7.7	Succin. soda	Blue or white	Protox. ——		
		with perox.	passing to blue	Perox. black	Black	Black
Manganese.....	8.	Tart. pot.	White.		White	Milkiness

PLATINUM.

Plataina, the ore of platinum, is found in the shape of small flattened grains of a steel grey colour, verging to silver white, possessing a metallic lustre, and in appearance much resembling clean iron filings; but at once known from them by their great specific gravity, which varies from 16. to 17.7. These grains are considerably hard and malleable, and are found in Choco, New Granada, and in the province of Barbacoas, also in the grey silver and copper ores of the Guadalcanel in Spain.

Pure platinum is never found in a natural state; the ore which comes to us not containing, in the best samples, more than 55 to 60 per cent. of this metal. It is one of the most compound minerals with which we are acquainted, the remaining sum of its weight being made up of gold, iron, lead, palladium, rhodium, iridium, and osmium, together with a portion of silica, intimately, and perhaps chemically combined. The whitest grains are the most valuable, generally containing the most gold, the quantity of which,

in some specimens, is sufficient to repay the after expense of reducing the whole.

Before the mouth blow-pipe, both the metal and the ore are perfectly infusible; and are acted upon, or dissolved, only by the nitromuriatic acid, and the solution of chlorine; from these the metal is again precipitated on the addition of a solution of muriate of ammonia, in the form of a yellow powder, the muriate of platinum and ammonia.

Tests for ascertaining the presence of Platinum.

The solutions of platinum are of a deep or brownish yellow, according to their purity.

Muriate of ammonia	Yellow precipitate, a triple salt.
Recent muriate of tin	Bright red colour with a very dilute solution.
Potassa ammonia, and some of their salts	Yellow precipitate.
Proto sulphate of iron, and salts with base of soda	No precipitate.

Ferrocyanate of potassa changes the colour from yellow to green.

Assay.

Platina being infusible by any heat we can obtain with a furnace, the assay must of necessity be conducted in the wet way, and as, (under this term is implied only the method of obtaining the quantity of the principal ingredient, the process is perfectly easy) provided in this case, we do not also imply, in the malleable state; to effect which there is more nicety required than in the purification and reduction of half the rest of the metals

Process.—A sample of the ore, say 100 grains, is to be digested, per retort, in ten times its weight of aqua regia of moderate strength, and which may consist of four parts muriatic and one part of nitric acids; apply the heat of a lamp, and draw over the one half into the receiver; decant the fluid remaining in the retort, and repeat the process with a fresh quantity of acid as before, and if necessary, a third time; the residue will now consist of a dark coloured powder which, not being platina, does not come within the assay. The solution containing the metal, which is of a deep brownish yellow colour, may be thrown

upon a filter, and after this has been well washed with distilled water, to collect every particle, a solution of muriate ammonia is to be added until the whole of the platinum is precipitated in the form of a yellow powder; this is to be collected, washed, and dried. The dried precipitate of the last process is now to be placed in a muffle and heated until all fumes cease to arise: the platina will remain in a spongy semi-metallic state, and the weight of it will show the per centage nearly of the assay: thus, if 55 grains are obtained in this state, it indicates 53 per cent. of metal, the remainder being oxigen. While still warm it may be amalgamated with mercury in a stone mortar, which will afterwards be expelled on the application of heat, leaving a porous mass of pure platina.

By means of the oxyhydrogen blow-pipe a perfect assay or metallic button can be readily obtained; if the precipitate just mentioned be placed upon a support of plaster of Paris or pumice stone, and then acted upon by the mixed gases, no reduction will take place; but if a drop of linseed oil, or a grain of charcoal powder is placed upon it, the metal is immediately obtained; the charcoal sup-

port produces the same effect, so also, does the admixture of a little sulphuret of potassa. I have found that by an apparatus, similar to the one described in the title page, but on a much more extended plan, and with ten jets playing at once, that a very considerable portion, (as much as fourteen ounces) may be reduced to a complete state of liquid fusion.

If, however, an exact analysis of the platina ore is required, in order to shew the number, nature, and quantity of each of the different substances contained, the task is much more tedious and complicated. To effect this, it is necessary, as in every other analysis, first to begin by testing a small portion of the liquid arising from the before mentioned digestion, thereby to ascertain what number of other metals are combined, and then to proceed in the best manner for obtaining their quantities.

Preliminary Process.—If a known quantity of the platina loses weight by being subjected to a red heat in a covered crucible, it shews that it was either not perfectly dry, or that it contained some volatile substance, and this may be either arsenic, sulphur, or mercury; if the first, it may be readily known by its garlic-like

odour; if the second, also by its odour resembling that of a common sulphur match when ignited, and its burning with a blue flame; if the third, by its silvering a piece of clean copper when held over it; arsenic, it is true, will also whiten copper, but the difference is immediately seen. I have stated that such substances might be contained in the sample, although, with the exception of water, owing to its having been kept in a damp place, and a small quantity of mercury, the effect of previous amalgamation to separate the grains of gold with which it is often found associated, I never found them.

Grain platina is frequently mixed with a portion of free iron and of sand fraudulently intermingled, in the same manner that opium sometimes contains bullets; these, however, are not of necessity chemically united, but are put to increase the profits either of the collector or the wholesale vender. Should the platina, however, be very impure, its low specific gravity, which should always be taken when purchasing a quantity, compared with what it ought to be, will at once show it; should this be the case, a good magnet may be em-

ployed to separate the first, and a small pair of hand bellows, upon an extended surface, the last.

Process 1.—Having by these processes, if necessary, collected the grain platina as free from heterogeneous particles as possible, the next step is to pour upon a given quantity, suppose 200 grains, a small portion of nitromuriatic acid somewhat dilute; this, upon the application of heat, will take up the gold, together with a small quantity of the platinum and the iron: a little solution of muriate of ammonia being now added, the platinum will be precipitated: it is to be collected on a filter, washed, dried, labelled, and put aside to add to those portions to be afterwards collected.

2.—The washings of the precipitate, being now added to the remaining solution, this is to be tested, and if nothing but gold and iron are contained, it may be evaporated to dryness, heated in a crucible, collected, and accurately weighed.

3.—The product of the last operation, and of which the weight is noted down, is now to be mixed with twice its weight of nitrate of

potassa, and fluxed in a crucible for half an hour with a good heat; on breaking this vessel to pieces, a button of pure gold will be found at the bottom, and which if deducted from the quantum last weighed, will give the oxyde of iron contained.

A second method of separating iron from gold when in solution, is to add the ferrocyanate of potassa, which throws down Prussian blue, but has no effect on the gold: the blue precipitate is, therefore, to be collected, well washed, dried and decomposed by heat in a crucible; the residue is oxyde of iron. The washings and solution containing the gold, when mixed together, may be decomposed by immersing a plate of clean iron, which will precipitate the gold in the metallic state, and which may be reduced to the malleable form by fusion with borax and nitre.

The gold being now removed, the analysis may be said to commence again, by digesting the residue of the platina, already once acted upon, in nitro muriatic acid of good strength; one or two digestions and elutriations are necessary, and when by these means the whole

of the matter soluble in acids is taken up, a small portion of the liquid is to be tested, and if it is found to contain lead, which is known by its giving a white precipitate with sulphate of soda, as much of this is to be added as will precipitate the whole; the liquid is now to be filtered, and the sulphate of lead well washed, dried and weighed.

4.—The solution separated from the lead, may now contain besides platinum, palladium, rhodium, and copper: to separate the first, a solution of muriate of ammonia, as before described, is to be added, until no further precipitate is thrown down; collected on a filter, washed, dried, and added to the smaller quantity previously obtained and put aside, it is to be further treated as in the assay.

5.—The chief part of the platinum separated, the solution containing the three other metals, is to be decomposed by immersing a plate of clean iron or zinc, which will precipitate the whole of them: collect this precipitate and digest in dilute nitric acid, this will take up the copper, which may

be precipitated in the metallic state by iron as before: collect, wash, dry, and ascertain its quantity.

6.—The residue remaining after the action of the nitric acid, is to be again dissolved in aqua regia, mixed with muriate of soda, (common salt) and evaporated to dryness. We now have the soda muriates of platinum, palladium, and rhodium; to separate these, digest the whole in alcohol, which will take up the two first and leave the last, which is to be again dissolved in water, and precipitated in the form of an oxyde by metallic zinc; it may be reduced to a button by fusion with arsenic, and again separated from this by long continued roasting.

7.—The alcoholic solution, containing the soda muriates of platinum, and palladium, is to be decomposed by muriate of ammonia, which will precipitate the first as before mentioned.

8.—The palladium may now be thrown down by a solution of the ferrocyanate of potassa, mixed with a small quantity of sulphur and well roasted, the metal will remain in a spongy but malleable state.

There remains now only the black powder,

the caput mortuum, after the digestion of the platina in nitromuriatic acid; and this consists of two metallic bodies, osmium and iridium, together with a small portion of silex.

9.—The osmium may be obtained in the form of an oxyde, by distilling the residual black powder with nitre in a retort. A sublimate will arise into the neck of the vessel, which is the oxyde of osmium: on cooling it will concrete into a semi-transparent colourless mass, which may be removed by breaking up the retort; its weight is to be taken.

10.—The iridium, not being soluble in potassa, will be found in the retort, from whence it may be extracted by dissolving away the alkali, together with any undecomposed nitre, it is to be well washed and dried.

The sum of the weights of the different products being now taken and added together, the amount should not fall far short of the original 200 grains, an allowance being made for the silex not collected, which was dissolved by the potassa in the 7th process, and this, if required, may be separated by supersaturation of the washings of process 8, with muriatic acid evaporating down to dryness, and ex-

posing to a low heat; upon elutriation with hot water and filtering, the silex will remain.

Reduction of the Platina Ore.

The process pursued by those few individuals who are at present engaged in the working of this peculiar metal from its crude state, for the use of the artizan, is still kept extremely close and secret. The fact is, although pure platinum can be easily obtained, (see assay) it is not so readily made compact and malleable; and this is not owing so much to any deficiency of chemical knowledge in those who have attempted it, as a want of the mechanical skill and power also necessary to produce the effect: and it may be said with regard to this metal, that those who wish to undertake its reduction, should unite a knowledge of chemistry with that of mechanics.

In the first place, the peculiarities of this metal should be well considered, and all attempts at the fusion (the rock on which so many endeavours have been lost) of so refrac-

tory a substance laid aside; unless indeed a furnace heat, equal to that of the combustion of the mixed gases, can be invented. That the oxyhydrogen blowpipe before alluded to will effect the reduction, is very well known; and as much as fourteen ounces can be fused at one time, with a powerful apparatus of this description: that masses so formed can be welded together, is also as certain; but after all the process on the large scale by this means, would be extremely tedious; although, perhaps, in time a facility of operation might be attained, together with an increase of power, hat would render this method not so defective as might at first be imagined. The chief part of the platinum that is used in this country, comes from France; and it has been asserted that the superiority of their manufacture, arises from the total use of charcoal heats, which as containing less sulphur and other impurities than coal, renders the metal tougher and more malleable. From a number of experiments made a short time since in my own laboratory, on upwards of 150 ounces, and in which I was assisted by a clever mechanic, I consider the following to be nearer the French

process, than I have ever before seen given in print.

Having obtained a considerable quantity of the yellow precipitate in a pure state, as directed in the assay, put it into saucers of half baked clay, (which may be 8 or 10 inches in diameter, by 3 or 4 deep) place a number of these so charged into a muffle, similar in shape to an enameller's, or a common baker's oven, and apply heat, until the whole of the muriate of ammonia is expelled, a side-opening for which should be made, communicating with a balloon receiver, in order that the salt may be collected, and which will serve for a second portion. The damper being now closed, and the fire allowed to go out, the plates when sufficiently cool are to be taken out and emptied of their contents. Before proceeding any further, it is necessary to observe that the admixture of any dirt, or of any foreign matter in this part of the process, will be sure to render the working in the after stage extremely difficult if not abortive.

The metal now in the form of a dark slate coloured powder, is to be boiled in clean water, acidulated with muriatic acid for half

an hour, in a clean unglazed earthen vessel—a platina one is preferable, as not liable to crack by heat. Decant the supernatant liquor and wash the powder with repeated quantities of boiling water, until the washings cease to give either a blue precipitate to ferrocyanate of potassa, or a white to nitrate of silver, thus showing the absence both of iron and muriatic acid. Now before the metal is taken out of the vessel, pour on it a concentrated solution of the subborate of soda (common borax) boil for a few minutes, and without washing, collect and dry.

Having proceeded thus far, a wrought iron tube perfectly clean within side, is to be provided, and which, for the first experiment, may be formed out of six or eight inches of a musket barrel, into the hollow of which, furnished with a stopper at the one end, and previously rubbed on the inside with a little powdered plumbago, force by means of a good screw-press, as much of the metal as possible. Provide now a clear charcoal fire, in a good blast furnace, into which place the tube, applying a very gentle heat at first; when the whole is red hot, and the particles of

borax appear oozing from the surface, remove it from the fire, and with the stopper and screw-press, force it to the utmost. The heating and pressure may be again repeated, after which the platinum may be removed; by striking the tube with a hammer in every direction, an ingot of metal is thus produced, which appears compact, and horny when at a full red heat, it is not, however, perfect, as if put into the flatting-mill it breaks in every direction. It is finished by alternately placing on the bare coals and intensely heating, removing to a polished anvil, and striking with a bright faced hammer. If this is repeated 18 or 20 times, taking care that the blows at first are very gentle, and gradually increased, that it is not struck except when at a white heat, and if care has been taken in the purification of the precipitate in the first instance, a good ingot will be obtained; the test for which is the flatting-mill; should this not be the case, and the metal turns out brittle, it must be broken up and subjected to the process of cementation, as with iron; if this does not correct it, it shows that it is alloyed with

some other substance, when the whole process of solution, &c. must be repeated.

Platinum is a metal which, when viewed as an article of commerce, may be regarded as still in its infancy; it is extremely useful to the chemist, and notwithstanding its high price, boilers made of it have been introduced into several manufactories for the preparation of acids and other substances, for which glass was formerly employed, and the durability of which is so very uncertain. Many attempts have been made to reduce the ore by cheaper methods than the one just described, but they have all failed in producing that perfect metal which alone is valuable, and to which no other approaches, with the exception of gold. The price will, no doubt, in time, be reduced, when it is more abundantly procured, and there are more manufactories for working it; but until that period, its utility will not be half known, or its value duly appreciated.

GOLD.

Although this metal is always found in a reguline state, it seldom occurs in that denominated pure gold, being for the most part alloyed with silver, copper, tellurium, or some few of the other metals. Native gold is that description, which, although united with silver or copper, does not contain such a quantity as to destroy its malleability, and is found in the crystalized, ramose, massive and granular forms. When, on the other hand, it is combined with tellurium, lead, or iron, it is known by the names of graphic gold ore, (from the peculiar arrangement of its crystals assuming a resemblance to writing,) auriferous galena, and auriferous pyrites, the analysis of which will be found under their respective metals. The great value which has always been attached to this metal, has occasioned its discovery in many parts of the world, particularly in the Brazils, Mexico, and Peru; also in the sands of many rivers in Africa, Sumatra, Japan, Transilvania, Hungary, Italy, in the county of Wicklow in Ireland, and

more or less in almost every country. It occurs in rivers, or dispersed through the substance of primitive mountains, particularly in argillaceus schistus, and clay porphyry, accompanied with felt-spar, calcareus and heavy spar, quartz, galena, pyrites, &c.

The specific gravity of gold ores varies from 12. to 19. Colours, gold yellow, brass yellow, greyish yellow, and pale brass yellow.

The varieties are—

Hexahedral, or native gold—gold with a minute portion of silver and copper.

Brass yellow native gold—gold with a little silver and iron.

Greyish yellow native gold—gold alloyed with platina.

Argentiferous gold—gold with a considerable quantity of silver.

Before the blow-pipe the whole are reducible into a metallic globule, consisting of the gold united to the alloy; the latter may be separated, silver excepted, by continuing the action of the exterior flame, with the addition of a little crude flux or nitre. Before the

oxyhydrogen blow-pipe, the metal is volatalized in the form of a purple oxide.

Tests for gold.

The salts of gold are of a pale or deep yellow tint; their solutions give with—

Proto sulphate of iron	Metallic gold.
Recent muriate of tin	Purple precipitate.
Potassa and soda	Yellow ditto.
Hydro sulphurets	Black ditto.

Solvent nitromuriatic acid.

Assay.

The assay of the gold ores already mentioned, is extremely simple and easy, and the only difficulty attending others which contain gold, the relative small proportion of this metal, even in those which are considered rich, and this quantity being often dispersed through an extremely hard matrix; when this is the case, it will be necessary to flux it, to effect which, first reduce a portion of the ore to a fine powder; take of this a given quantity, mix it intimately with four times its

weight of dry caustic potassa, or with a solution containing this quantity, and to which a little borax may be added; place this mixture in a good crucible, reduce to dryness and expose for an hour to a bright red heat, at the end of which time the fusion should be complete, and the metals contained in the ore in a button at the bottom of the vessel. If this is, however, not the case, it shows that a sufficient heat has not been given, when the process should be repeated; but if this is not convenient, the crucible and contents may be placed in an iron vessel containing water, and boiled until the whole of the flux is dissolved, and every particle is detached from the crucible, the residue is now to be taken out and collected together.

The button resulting from perfect fusion, or the residue insoluble in the boiling water, is now to be digested with heat in a sufficient quantity (8 or 10 times its weight) of a nitro muriatic acid, rather dilute, and this process continued until the whole is taken up, or all action ceases. If a white flocculent precipitate remains, it is silver, but which has no connexion with this assay; pour off the clear liquor, elutriate any residue there may be,

add the washings to the first solution, and pour in a solution of the proto sulphate of iron until no further precipitation ensues, collect on a filter, elutriate, mix with half its weight of nitre, and a little borax, and reduce as before. A button of pure gold will remain.

Should the ore be found not to contain silver, the assay may be varied as follows: the ore having been reduced to powder and fluxed, the residue may be alloyed by fusion, with twice its weight of lead, and submitted to cupellation, the lead in this case vitrifies, carrying with it the baser metals; it may also be done, although not so eligibly, by repeatedly injecting pieces of nitre on the fused mass, which will oxydize and vitrify the impurities, the gold remaining behind.

Assay of gold dust.

If on the contrary, the particles of gold exist in a divided state, and free from matrix, as in stream gold, the fluxing is not necessary. Cupellation, as before described, being quite adequate to its purification, provided it con-

tains neither silver nor platina. Should the cupel not be at hand, or the gold dust, contain either of the just named metals, a given weight, (say 100 grains,) is to be digested with nitro muriatic acid, the solution precipitated with proto sulphate of iron, and fused with nitre and borax, the residue is the gold contained; the silver in this instance will remain on the filter in the form of a white powder (or chloride) and which, when washed and dried. may be reduced with a little black flux to the metallic state. The platina, if contained, is to be precipitated with muriate of ammonia. as described under that article.

The purification of gold and silver constitutes the business of the refiner, to whom the former comes in an alloyed state, either with copper, silver, or both combined; but so little is he in general acquainted with chemistry. that unless the article is known to be standard by the Hall mark, it is commonly sent to be assayed previous to his purchase. If the gold is alloyed only with copper, cupellation or purification with nitre and borax is alone necessary; but if it contains silver, the processes of quartation and parting are used; the main

object in all cases being to refine at the least possible expense, for this purpose it is first necessary to ascertain in what proportions the silver exists, and if in only a third part, the addition of three more parts is necessary, so that when fused together, the mass consists of two thirds silver and one gold.

The intention of this is so far to separate the particles of gold from one another, that in parting or when rolled out into thin sheets, and exposed to the action of nitric acid, this metal. itself insoluble in the menstruum, shall be incapable of defending the silver from its action, which is therefore dissolved, leaving the gold in a pure but spongy state.

Analysis of native gold.

To make an exact analysis of native gold. which is generally this metal alloyed with silver and copper.

Process 1.—Digest a given quantity with such an addition of nitro muriatic acid as will decompose the whole, the residue will be the silver contained in the form of a chloride; this when collected, washed, and dried, may

be estimated at three-fourths silver, or it may be reduced by heat and black flux.

2.—The remaining solution to which the washings of the silver have been added, is to be decomposed by proto sulphate of iron, the gold will fall, which is to be collected, washed and dried.

The liquor now remaining contains only the copper and such iron as was inserted for the separation of the gold, and of which latter no account is to be taken. The former may be separated by immersing a clean plate of iron, and gently heating the solution, the copper will be precipitated in the metallic state; it is to be collected, washed, and dried.

The sum of the weights of the products being now taken, it will indicate the quantity of the different metals contained in the specimen.

The analysis of gold dust may be effected in precisely the same manner.

Reduction of gold ores.

The ores of gold are reduced in the large way, either by amalgamating with mercury, or by fusion with lime and vitrifiable matter

the first process being applicable to those ores containing native gold, and the second to auriferous pyrites.—Amalgamation is thus performed:—

The ore having been brought to the surface, the larger masses are broken up with sledge hammers by the workmen, who afterwards reduce it into pieces not larger than a walnut, these are sorted according to their supposed relative value, and subsequently sent to the mill, where they are reduced to the state of fine powder. When this has been effected, it is generally washed, to separate as much of the light stony matter as possible, which is done either with a machine called a sweep-washer, or more simply by placing the ground ore in a shallow vessel with two handles, which, when immersed in a tub of water or running stream, and a kind of rotary motion applied, separates the lighter from the heavier particles. The residue left from the washing, is to be dried and mixed with a sufficient quantity of mercury to amalgamate the gold and silver contained; to favour which, a gentle heat may be applied to the mass for two or three days, at the end of which the fluid

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amalgam is to be poured off and pressed in a skin of leather, this will separate a considerable part of the mercury, which is again applied to the same purpose, and distillation of the residue left in the skin the remainder; the gold is now left in an impure state in the retort, it may be purified by cupellation or quartation as before described. In this simple way the greater part of the gold which comes from South America is obtained, and the process depends upon the strong affinity which mercury has for the precious metals.

Uses of this metal.

The purposes to which gold is applied are too well known to need any description; its malleability and ductility are so great that it may be extended into leaves not more than the three hundred thousandth part of an inch in thickness. Ether, Naptha, and essential oils take the gold from its solution in nitromuriatic acid, again leaving it by evaporation, and this is the case with no other metal excepting platina.—The purple precipitate of Cassius, which is made by adding

protomuriate of tin the solution of gold in aqua regia, is used in the arts.

SILVER.

The ores of silver are rather numerous and are found in almost every country, but particularly in Mexico, Peru, Saxony, Bohemia, the Hartz, and Guadalcanal in Spain; also in France, Norway, and Siberia: it has also been found in Cornwall and Devonshire. The ores may be arranged under the following heads, which do not include the lead varieties, in which the metal exists in very small quantities.

Native silver—silver with small quantity of antimony.

Auriferous silver—silver and gold.

Sulphuretted silver—silver and sulphur.

Brittle sulphurotted silver—silver, sulphur, antimony, and iron.

Red silver—silver, sulphur, antimony, and oxigen.

White silver—silver, sulphur, antimony, and lead.

Bismuthic silver—silver, sulphur, bismuth, and lead.

Carbonate of silver—silver, carbonic acid, antimony, &c.

Muriate of silver—silver and muriatic acid.

In the crystalline, massive, disseminated, and many other forms.

Native silver is generally pretty pure, not containing more than 1 or 2 per cent. of alloy; which consists of antimony, with a little copper, and alumina.

The specific gravity of silver ores varies from 5.0 to 10.4; the colours are white, pale yellow, dark lead grey, bluish black, light lead, and ash grey; generally glistening and metallic. They are all reducible to a bead by the action of the blow-pipe on the charcoal support. The ores of silver are not peculiar to any one soil, being found in granite, gneis, mica, and clay slate; clay, porphyry, &c. It generally occurs in primitive mountains.

Tests for silver.

The solutions of silver are white, giving a permanent black stain to the skin.

With the alkalies	Dark olive precipitate.
Plate of iron or copper	Metallic silver.
Ferrocyanate of potassa	White precipitate.
Muriatic acid and salts of	White ditto, soluble in ammonia.
Tincture of galls	Brown precipitate.
Hydrosulphur. ammon.	Brownish black.

Assay.

Silver not being acted upon by the fixed alkalies, renders the assay of its ores extremely easy, nothing more being necessary, after previously roasting, to separate any sulphur or arsenic that may be contained, than to reduce it to fine powder mixing it with three or four times its weight of caustic potassa or soda, in a crucible, and applying a sufficient heat in a portable furnace the metal will be found at the bottom; if not pure it is either to be cupelled with lead as before

described under the article Gold, or fused with repeated additions of nitre in a crucible. Assayed in the wet way, it may be dissolved in pure nitric acid, precipitated with common salt—the precipitate collected, dried, and mixed with a little crude flux or pearl ash and again fused; the button now obtained is pure. and its weight will indicate the per-centage in the ore. If any gold has been contained, it will be left undissolved in the form of a black powder.

The nitric acid here used should be very pure.

Before the oxyhydrogen blow-pipe silver burns with a beautiful green light, and is, at length, entirely dissipated.

Analysis.

To make an analysis of the silver ores, the following examples will point out the method of operating:—

EXAMPLE 1.—100 Grains of the crystallized auriferous silver, which upon trial was found to contain only gold, silver, and copper, were put into a mattrass with two ounces of

nitromuriatic acid rather dilute, and heat applied. Nitrous gas was disengaged, and white curds floated in the solution; when cold, the whole was thrown upon a filter; the residue, well washed and dried, was chloride of silver: and this was afterwards reduced to the metallic state with a little black flux in a crucible.

2.—The washings of the silver being added to the clear filtered liquor, a solution of proto sulphate of iron was poured in until no further precipitation took place; the precipitate was collected by decantation, and after well washing was reduced with nitre and weighed.

The remaining solution now containing the copper, after the last washings had been added, was decomposed by a clean plate of iron, which threw down the copper in the metallic state, it was collected, dried and weighed; the sum of the weights indicated three fourths of a grain loss.

1.—*Antimonial Silver.*—100 grains of this variety were digested in 10 times the weight of nitric acid; a portion of the ore was left behind, which, when collected on the filter, washed, and dried was silex.

2.—The washings of the silex being added to the strong solution occasioned a turbidness, more water was therefore added and a precipitate fell; it was the oxyde of bismuth contained in the ore.

3.—Muriate of soda was now added, which threw down the whole of the silver, and which upon being washed and dried was estimated as three fourths metal.

Another specimen of antimonial silver was afterwards taken, which, upon testing, was found to contain silver, antimony, iron, sulphur, copper, and lead.

1.—200 grains of the finely divided ore were digested with dilute nitric acid, which took up the whole, excepting the sulphur and a small quantity of siliceous matter, the matrix of the ore; this was gently dried and weighed, afterwards submitted to a red heat and weighed again; the sulphur was thus burnt off and its quantity estimated.

2.—The clear liquor was now largely diluted with water, which precipitated the antimony in the form of an oxyde, it was collected, washed, dried, and the liquor concentrated by evaporation, which then let fall a little more

oxyde of antimony.—One hundred parts of the oxyde are equal to about seventy-six of metal.

3.—The solution, now containing four metals, was partly decomposed by sulphate of soda, this threw down a white precipitate, the sulphate of lead, it was dried, and its value estimated by the scale of equivalents.

4.—The washings of the last process being added to the remaining solution, muriate of soda was added, this precipitated the silver, which was washed, collected, and reduced as usual.

5.—To the remaining liquor, now holding the iron and copper, caustic ammonia was added in excess, and the mixture heated. The iron was thus precipitated, and which, after washing and drying was mixed to the consistence of a paste with linseed oil, and heated until magnetic; being now in the metallic state, its weight was ascertained.

6.—The ammonical solution remaining after the iron had been separated, was supersaturated with nitric acid, and the copper precipitated by a clean plate of iron.

7.—The sum of the weights of the products

being now taken, and indicating a greater loss than usual, the solution was again tested; as no metal was however contained, nitrate of barya was added, which occasioned a white precipitate of sulphate of barya, which, when washed and dried was equal to four grains of sulphur, and which had been acidified by the first process of digestion in nitric acid.

Red silver ore—generally consists of silver united with sulphuric acid, sulphur, and antimony; or what is the same, silver, antimony, sulphur, and oxigen, it may be analysed as follows:—

Process 1.—A portion of the ore, previously levigated, is to be placed in a mattrass or flask; five or six times its weight of dilute nitric acid poured upon it and heat applied; if not sufficiently decomposed by this quantity a further portion of acid must be employed, but any great excess is in this case to be avoided as it will acidify the free sulphur contained in the ore. A solution of the metallic part being thus effected, it is to be diluted with water and filtered, taking care not to add so much of this latter as will occasion a cloudiness; the residue, when washed and dried, is the

sulphur together with the matrix of the ore; it is to be weighed and the sulphur burnt off, the quantities of which are thus estimated.

2.—The solution, now containing only antimony, silver, and sulphuric acid is to be treated as in the second, fourth, and seventh processes of the preceding analysis.

Bismuthic Silver.—In this ore the silver is alloyed with bismuth, sulphur, lead, and sometimes iron and copper. The analysis is to be conducted in precisely the same manner as in the second example given of this metal; the bismuth being precipitated by water in the same way as the antimony.

Corneus Silver.—This is one of the richest of the silver ores, containing often 75 per cent. of metal.

To ascertain its composition.

Process 1.—Mix the powdered ore with four times its weight of carbonate of soda and flux in a crucible for half an hour; when the fusion is complete, dissolve out the mass with boiling water, and edulcorate the residue; the remaining portion is to be digested in nitric acid; the silver precipitated with muriate of soda, and reduced as before.

2.—The alkaline liquor containing the muriatic acid of the ore, in combination with soda, together with some portion of free alkali, is to be brought to the point of saturation with distilled vinegar; if alumina was contained in the ore, as it frequently is, it will be precipitated in the form of a white flocculent powder, which is to be collected on a filter, washed, dried, and weighed.

3.—The remaining solution is now to be evaporated to dryness, and the mass digested for several days in good alcohol; this will take up the uncombined alkali, and muriate of soda will remain, 58 parts of which, are equal to 24 of muriatic acid; or, this process may be varied and much shortened, by adding to the alkaline liquor nitrate of silver, every 100 parts of the precipitate will indicate 25 of muriatic acid.

4.—If sulphuric acid has been contained in the ore, which is generally the case, although in very small quantities, the salt remaining after the alcoholic process, is to be dissolved in water, and tested with acetate of barya; the sulphate will thus be thrown down, and its equivalent may be ascertained.

Grey Silver Ore, or Carbonate of Silver.—This variety is easily reducible *per se* by heat; if any other metals are contained, the mass is to be dissolved in nitric acid, tested for them, and the analysis conducted as in the preceding examples. If the quantity of silver only is required, it may, in common with all the other silver ores not containing gold, be obtained by cupellation; but as this ore seldom contains besides silver, any other substance than antimony and carbonic acid, it will not after what has been already said, be necessary to give any analysis.

Uses of the Metal.

Silver not being easily tarnished by exposure to air, and possessing a considerable degree of metallic splendour, is used in the manufacture of trinkets, as well as the making of coin; for the latter purpose it is alloyed with a small quantity of copper to increase its hardness, and consequent durability. It is extremely tough and malleable, although not in so great a degree as gold, it does not furnish the artist with any good colour; but its

solution in nitric acid, is used to impress indelible characters on linen, cotton, &c.

PALLADIUM.

This new metal was first discovered by Dr. Wollaston, in his researches into the nature and constituents of the platina ore. This gentleman has also ascertained its existence in the native state, in the form of small grains, alloyed with a small quantity of platinum and iridium. It is of a steel grey colour, possessing a metallic lustre and fibrous fracture. Specific gravity a little greater than silver: it is peculiar to the alluvial gold districts in Brazil.

Before the blow-pipe palladium is infusible, but when heated in contact with sulphur or arsenic, it runs into a brittle mass; the latter is again driven off by continuing the heat, leaving the metal in a porous and slightly malleable state.

Tests.

Prussiate of mercury	Yellowish white precipitate.
Prussiate of potassa	Olive.
Sulphuretted hydrogen	Dark brown.
All the metals except gold, silver, and platina	Metallic palladium.

The best solvent for palladium, is the nitro muriatic acid, with which it forms a deep red solution; it is also but feebly acted upon by the muriatic, nitric, and sulphuric acids, which take up a small quantity of it.

Assay.

The native ore of palladium, may be assayed by solution in nitro muriatic acid; and precipitating by prussiate of mercury. The yellowish white powder thus obtained is the prussiate of palladium, and which by exposure to heat will be decompósed, the acid flying off and leaving the metal pure. For the methods of separating it from platina, rhodium,

iridium, and osmium, see the article Platina. Pure palladium is ductile and malleable, and when rolled into sheet is flexible, considerably harder, and more elastic than platina; before the oxyhydrogen blow-pipe, it readily fuses. This may also be effected in a wind furnace; the button thus obtained is of a dull white, with a specific gravity about 11.

RHODIUM.

This metal was also discovered by Dr. Wollaston, in the ore of platina: it may be obtained as before mentioned in the analysis of that metal. It appears infusible even before the oxyhydrogen blow-pipe; but may be easily combined with arsenic, which renders it extremely fusible: the greater part of this may be again driven off, by exposure to a long continued low red heat, by which it is volatilized; leaving the rhodium as a striated and rather porous mass, but sufficiently hard to scratch glass.

The specific gravity of this metal, is about the same as that of palladium: when the

oxyde is heated with borax, it assumes a white, shining, and metallic appearance; it is soluble in most of the acids: these solutions do not afford crystals by evaporation; but give a fine rose red colour to water and alcohol, from which circumstance its name, rhodium.

Tests for

The triple salt with soda is crystallizable; but takes several days before the crystals make their appearance.

Alcohol and water	Rose red solutions
Caustic alkalies	Yellow oxyde soluble in excess of.
Solution of platina	Yellow precipitate.

Assay.

If it is wished to determine the quantity of this metal existing in the platina ore, without any reference to the other constituents, it may be performed thus:—

Process 1.—A given quantity of the crude platina ore, is to be digested in nitro muriatic

acid, which will take up the platina, palladium, and rhodium: add to the clear solution muriate of ammonia, the platinum will be precipitated.

2.—Decant the clear liquor, and immerse a clean plate of zinc; a black powder will fall, which is to be digested in dilute nitric acid, to separate any copper or lead that may have been contained in the ore. Digest again in dilute nitro muriatic acid; add some common salt, and evaporate to dryness.

3.—The dry mass in process 2, is to be digested in alcohol; a red substance will remain, which is to be dissolved in water again precipitated with zinc, mixed with borax, and strongly heated; the residue will be the rhodium.

IRIDIUM.

Which has been before noticed under the article Crude Platina, and of which it constitutes a small portion, was first ascertained to be a distinct metal, by Mr. Tennant, who pub-

lished his analysis of the black powder remaining after digesting the grain platina in nitro muriatic acid. For the method of procuring it, see that article.

Iridium is also supposed to exist in the form of an alloy with osmium, uncombined with the other metals: this compound is hardly distinguishable from the other grains of platina with which it is mixed, but by its difficult solution in acids; when, however, more narrowly examined, the grains will be found to be of a darker colour and extremely brittle, which is not the case with those of platina.

The specific gravity of these grains is 19.5.

Iridium unites with most of the metals forming with gold, silver, and copper, malleable compounds; in this respect it differs from platina, the alloys of which are hard and brittle.

The name iridium was given by its discoverer, on account of the great variety of colours it exhibits while dissolving in muriatic acid.

Tests for

Tincture of galls	instantly destroys the red colour of the solution.
Ammonia and the fixed alkalies	Yellow precipitate.

Pure iridium is white, it does not enter into direct combination either with sulphur or arsenic.

OSMIUM.

So called from the peculiar pungent smell of its oxyde, is the last article to be mentioned as forming a part of the platina ore. It may be procured as mentioned under the head of that article. Its oxyde is soluble in alcohol and water, and this solution gives a dark stain to the skin as permanent as that produced by nitrate of silver.

To obtain the osmium from the oxide, the solution of it may be shaken with mercury; an amalgam of the two metals will be formed which may be separated into its constituent parts by distillation in a retort.

Tests for

The solutions of the oxide of this metal give out a peculiar pungent odour.

Infusion of galls,	Purple changing to blue.
Lime, ammonia, and carbonate of soda,	Yellow solution.
Solutions of lead,	Yellowish brown.

The peculiar characteristics of osmium, which is of a dark grey colour, are insolubility in acids, but ready solubility in potassa; its great susceptibility of oxidation, its volatility, and the peculiar smell of its oxide.

Note.—The four newly discovered metals in the platina ores have not been obtained as yet in sufficient quantities to enable us to ascertain whether they will prove of much use to society. The only experiments on this sub-

ject at all interesting to the public, were made by Messrs. Faraday and Stodart, on their combination with steel, for the improvement of cutting and surgical instruments, &c., and published in the Transactions of the Royal Society a short time since.

MERCURY.

Mercury, commonly called quicksilver, is found native in the pure metallic state, but the source from whence the greater portion is obtained, is from the sulphuret of the metal or native cinnabar.

Fluid mercury is between tin and silver white. It is collected in globules in cavities, or holes dug in the earth for the purpose. The principle mines which furnish this metal, are those in Idria, Deux Ponts, Almaden, and Guanca Vellica; it is not peculiar to any one soil, being found in quartz, indurated clay, argillaceous schistus, calcareous spar, &c. &c.

The ores of mercury may be divided into—

Metallic mercury	
Native amalgam	Mercury and silver

Cinnabar	Mercury and sulphur,
Horn mercury	Mercury oxygen, muriatic and sulphuric acids.

In the state of fluid, semi-fluid, crystallized, massive, fibrous, pulverulent, investing, &c.

Most of the ores of mercury are readily distinguished from those of any other metal; in the first variety globules of the metal are seen attached to or just starting on the surface, which is at once a sufficient criterion, mercury being unlike every other metal; in the second, by the fine white colour, and the action of the blow-pipe, which sublimes the mercury and leaves the silver behind; the third, by its beautiful deep red tint, varying from cochineal to scarlet red, excepting in those termed hepatic cinnabars, which are generally of a lead grey; the fourth, by its light grey colour, its partial solubility in water, and its complete volatilization by heat, emitting at the same time an arsenical odour. Before the blow-pipe, these varieties burn with a blue flame and sulphurous odour, leaving more or less residue behind them, and which may consist

of earthy matter, as silex and alumina, together with the oxides of iron and copper.

The specific gravity of the mercurial ores varies from 6.5 to 10.5; that of the pure metal, as revived from its oxide, being 13.5.

The action of the blow-pipe on the ores of mercury has already been stated; a very ready method of collecting the sublimed metal, is to place a portion of the ore at the bottom of a small test, or other tube, closed at the one end and loosely stopped by the finger at the other, a slip of clean sheet copper being previously inserted, if the flame of the blow-pipe is now driven on the sealed end of the tube, the mercury will sublime and attach itself to the copper. It is to be remembered that this method is only applicable to the first and second varieties; but the others may be treated in the same way if previously mixed with a little protoxyde of iron, or a few grains of clean iron filings, and if care has been taken in gradually raising the heat, and the tube remained sound as before the increased weight of the copper, will pretty accurately give the quantity contained; if any globules should appear attached on the inner

surface of the glass tube, that part of it which holds the impurities of the ore is to be cut off with a file, and the remainder accurately weighed, it should then be well cleaned and reweighed, the loss will give the mercury attached.

Tests for.

The presence of this metal when in solution may be detected by—

A plate of copper,	Metallic mercury.
——— iron,	Dark powder changing into fluid mercury when triturated
Fresh lime water,	Orange precipitate.
Ferro prussiate of potassa	White ditto.
Hydro sulphurets,	Black ditto.
Gallic acid,	Orange yellow.

Assay.

The assay of the ores of mercury in the minute way has been already mentioned, the quantities may be enlarged if an iron retort is used instead of the glass tube; on a more extended scale, see reduction of

Analysis.

The analysis of the ores of mercury is very simple, seldom containing more than six, and often only two foreign substances.

The analysis of the native mercury need hardly be mentioned, as however, it sometimes contains a minute portion both of silver and bismuth, it may be thus conducted:—

Process 1.—Place a small portion, say 100 grains, in a small flask set in the retort stand, pour upon it by small quantities at a time, pure nitric acid a little diluted until the whole is dissolved, pour this into another glass vessel holding about a pint of clean distilled water, the oxide of bismuth will fall; filter and collect; wash until tasteless; dry and weigh. The washings of the filter being added to the other solutions, the whole is to be evaporated to one half; when, if any further precipitate is given, it is to be collected as in the preceding and added to it.

2.—The solution now containing only silver and mercury, is to be decomposed by muriate

of soda; muriate of silver will fall; collect, &c. as before.

3.—The washings of 2 having been added to the remaining solution, carbonate of potassa, will throw down the mercury, which when heated with a little charcoal, will give the metal in a fluid state.

Native amalgam.

The analysis of the native amalgam is precisely the same, the foreign matters only entering in larger quantities; for the sake of variation, however, the following method may also be adopted.

Process 1.—Proceed exactly as in process 1 of the former analysis, which will get rid of the bismuth; and evaporate to dryness.

2.—Mix the dry residue, consisting of the oxides of silver and mercury, with a little charcoal powder, and submit to a low red heat in a coated retort; the mercury will distil over, and a button of silver will remain behind.

Native cinnabar.

The analysis of native cinnabar, or sulphuret of mercury may be thus effected.

Process 1.—A given weight of the ore reduced to powder, is to be digested with heat in muriatic acid, adding occasionally a few drops of nitric acid to effect a solution; when the action of the acid ceases, and a few drops more of fresh nitric acid produce no effect, pour off the clear liquor, edulcorate the residue, and dry with a gentle heat; this will consist of the sulphur with any siliceous matter insoluble in the acid, the separation of which may be readily effected by heating them in a platina dish or the bowl of a tobacco pipe, the sulphur will then burn off, and the loss in weight upon reweighing will indicate the quantity contained.

2.—The nitric solution is now to be tested, and if found to contain only mercury, iron, and copper, the solution may be evaporated to dryness, taking care not to give so much heat as would decompose the mercurial salt; upon resolution in distilled water the chief

part of the iron will be left behind in the state of per oxide.

3.—Immerse into the solution a clean plate of iron, and gently heat it, the mercury and copper will fall down: the precipitate thus obtained is to be well washed, dried, weighed, and ignited, the residue left after this will be the copper, and the difference in weight before and after ignition will give that of the mercury.

Or, after process 1, decompose the solution by adding ammonia in considerable excess, which will throw down the iron and mercury, separable by heat, while the copper will remain dissolved. Super saturate the ammonia with any acid, immerse a clean plate of iron, and the copper will be obtained in its metallic state; if any sulphur has been acidified in the process, it may be thrown down by nitrate of barya.

Horn mercury.

This variety is a muriо sulphate of the metal, and its constituent parts may be thus ascertained:—

Process 1.—Having reduced a portion to

fine powder, digest it in good acetous acid; if any metallic mercury has previously existed, interspersed through the substance of the ore, it will be left behind, and is to be collected, washed and dried.

2.—To the clear solution add nitrate of barya, which will throw down a white powder, the sulphate of barya, collect, well wash and dry on a filter; every 100 parts indicate 34 of dry sulphuric acid, or thirteen and a half of sulphur.

3.—Add the washings of the last precipitate to the remaining solution, and drop in nitrate of silver until no further precipitation takes place; this is the muriate of silver; 100 parts of which, when washed and dried, are equal to 25 of acid.

4.—Add the washings of the last process as before, and precipitate the mercury still in solution by a plate of clean iron. The powder obtained when dried and triturated will assume its characteristic fluidity.

Reduction of the ores of mercury.

The processes adopted for the extraction of this metal from its ores, although varied a little in the different countries in which they are found, are all, however, extremely simple.

The ore, after it has been sorted, and those pieces which appear destitute of metal thrown aside, is afterwards ground to a coarse powder, and well mixed with from one-eighth to one-fourth its weight of fresh slacked lime. Iron retorts capable of holding 80 or 90 pounds weight of this mixture, are now charged, after which they are placed in a long furnace, built for the purpose, and heat gradually applied, until the whole of the metal has distilled over into receivers connected with the beaks of the retorts on the outside. When the vessels are cool, they are emptied of their contents, and are again set to work as before. This is the process usually adopted with the cinnabars, the lime, in this case having a much stronger affinity for the sulphur than the mercury, combines with it, and fluid mercury results. This method also answers very well

for the fourth variety, simple distillation without addition being sufficient for the first and second.

Uses of mercury.

The purposes to which this metal is applied are numerous and important. In combination with acids it forms salts, the number of which, when added to that of its oxides, and to those formulas where the metal exists in a minutely divided state, form together a very numerous class of medicinal preparations well known for their peculiar energy on the animal economy. Mercury is also used in the manufacture of barometers and thermometers, for silvering mirrors and looking glasses. In the laboratory it furnishes a ready method of collecting those gases which are easily absorbed by water.

NICKEL.

Nickel is found very abundantly in Germany, where it occurs generally in the form of a sulphuret, and is called, by the Germans, kupfernickel; a combination of this metal and sulphur, is found also in Saxony, Cornwall, France, Spain, and Siberia; besides this variety we have—

Native nickel,	Nickel with a very small portion of arsenic and cobalt.
Black ore of nickel,	Nickel arsenic oxygen.
Nickel ochre,	——— iron & oxygen.

Native nickel is found in the mines in the form of capillary crystals, of a brass yellow colour, these are brittle, and possess a shining metallic appearance, attractible by the magnet and of the specific gravity 6. 5.

Kupfernickel is of a pale copper red colour, possessing a metallic lustre; its feature is coarse grained, shining and metallic, it is

sufficiently hard to produce fire with a steel, and varies in specific gravity from 7.4 to 7.8.

The black ore of nickel is of a dark grey colour, passing to black; it is soft, slightly soiling the fingers, gives a shining streak with the point, and has an earthy fracture.

Nickel Ochre.

Nickel Ochre has generally an apple green colour, is soft, has a meagre feel, and splintery fracture; it is found in the Lead Hills and in Saxony.

The specific gravity of the ores of nickel vary considerably, that of the pure metal being 8.6.

Tests.

The solutions of the salts of nickel are of a green colour, possessing an acrid sweet taste; they give with

Hydriodic acid	Pea green iodide,
Ferro prussiate of potassa	Green precipitate,

Hydro sulphuret of Ammonia	Black,
Ammonia	Green, re-dissolved by excess of

Nickel.—Action of the Blow-pipe.

Before the blow-pipe, the greater part of the ores of nickel give off sulphurous and arsenical fumes, and there remains a dark slag interspersed with metallic grains. The ores are sometimes of a very compound nature, often containing, besides nickel, arsenic, sulphur, iron, cobalt, copper, and sometimes bismuth and silver, besides quartz and alumina. The pure oxide is not affected by the common blow-pipe, but with borax it fuses readily into a glass of a yellowish tinge, which nearly vanishes on cooling. If the borax is overcharged with oxide, the glass is opaque whilst in fusion, but on cooling, it again becomes transparent and of a dull red; when urged by the inner flame the metal is reduced and the mass turns to a steel grey.

Assay.

Nickel is one of those metals, the thorough purification of which presents many little difficulties to the operator; it is magnetical, and even acquires polarity by the touch; it is infusible under an intense heat, after which it is malleable, and assumes a white colour between that of silver and tin.

Process 1.—The sulphuret of nickel being reduced to powder, is to be mixed with charcoal and well roasted, by this means the greater part of the arsenic and sulphur will be separated.

2.—Mix the roasted ore with twice its weight of black flux in a crucible and submit it to a strong heat for half an hour in a furnace, a small quantity of common salt thrown in when nearly finished will make the whole more fluid, and allow of the better separation of the metal.

3.—The button of metal thus obtained is to be digested in nitric acid and evaporated to dryness, the residue to be boiled in caustic

ammonia, and the clear solution again evaporated to dryness, then mixed with half its weight of black flux and exposed to a violent heat; a button of pure metal, if no cobalt has been contained in the ore, will be the result.

Dr. Thompson recommends simply to act upon the ore with sulphuric acid, by which means, a crystalized sulphate will be obtained; this is to be dissolved in water, again crystalized and dissolved, when, on the addition of a caustic alkali, oxide of nickel will precipitate, and this, upon being mixed with a little oil and three or four per cent. of resin, to the consistence of a paste and exposed to a strong heat, will give a button of pure metal.

Analysis of the Sulphuret of Nickel.

This being the most compound variety, an analysis of it will shew the method with the others: supposing it be found to contain on trial, besides nickel, arsenic, sulphur, iron, cobalt, copper, bismuth, and silver; we shall thus proceed:—

Process 1.—Having reduced a certain por-

tion to fine powder in a hand mortar, digest it in successive portions of dilute nitric acid until all action ceases, and until every thing soluble appears to be taken up, the residue will consist of the silex and nearly the whole of the sulphur; separate these by burning off the latter; estimate the quantities of both, and note them down; should the nitric acid have left any thing else but these two behind, it is again to be acted upon by nitromuriatic acid, keeping the solutions separate.

2.—Neutralize any great excess of acid there may be, by the cautious addition of a solution of pure soda, taking care not to add so much as will produce an opacity; and throw the whole into four or five times its quantity of distilled water; a white powder will now fall, which is the oxide of bismuth; proceed in the same manner with the other solutions; evaporate to half the bulk, and add any precipitated oxide that may fall to the first quantity obtained.—123 parts of this oxide are equal to 100 of metal.

3.—Mix the two solutions with the washings in the last process, and if the silver contained in the first is not easily thrown down by the

muriatic acid contained in the second, add solution of common salt until the whole is obtained, and the supernatant liquor speedily becomes clear:—100 parts of this muriate of silver are equal to 75 metal, and may, if wished, be reduced to the metallic state by fusing with a little black flux.

4.—Mix the washings of the last process with the remaining solution, evaporate to dryness, and digest the residue repeatedly in strong nitrous acid; evaporate again to dryness, re-dissolve, and filter; the iron will remain in the state of a peroxyde.

5.—The liquor, now holding arsenic, copper, nickel, and cobalt, is to be nearly saturated with soda, avoiding so much as will cause any cloudiness; nitrate of lead, now added drop by drop, will precipitate arseniate of lead, the weight of which is to be taken and the quantity of arsenic estimated.

6.—The copper may now be separated from the solution by immersing a plate of clean iron, which, after standing a few hours with the addition of a little heat, will precipitate the whole of it.

7.—The iron introduced in process 3, is now

to be removed by supersaturating with ammonia, the liquor filtered, and the excess of volatile alkali expelled by a gentle heat; upon the addition of a very dilute solution of caustic potassa, the oxide of nickel will be separated, for the reduction of which to the metallic state, see assay.

8.—The liquor, now holding only cobalt, is to be saturated with nitric acid; upon the addition of carbonated soda this will also fall.

The demand for this metal has been as yet too trifling to induce many trials to reduce it on an economical scale in this country, although its alloy with copper possesses a superiority in point of durability of colour over that of plated metal, and might be applied to many useful purposes.

COLUMBIUM.

The metal which bears this name, was first obtained by Mr. Hatchett, from a mineral found in Massachusetts, and deposited in the British Museum. In this specimen the columbium is united to oxygen and iron, it was therefore considered as an acid, and accordingly denominated columbic acid. This ore was afterwards ascertained to be identical with the oxide of a metal found in a mineral designated Yttrotantalite, by Mr. Ekeberg, who gave it the name of Tantalum.

Collumbium is of a dark grey colour, possessing a metallic lustre, much resembling iron; its specific gravity about 5.6; brittle, and sufficiently hard to scratch glass. At a red heat it absorbs oxygen, and passes into the state of a white oxide. In the metallic state it is insoluble in acids, but the oxide is slightly acted upon by the muriatic. It has been discovered in no other mineral than the

Yttrotantalite, found at Ytterley in Sweden, which consists, according to Ekeberg, of

Oxide of columbium	80
——— iron	12
——— manganese	8
	100

Tests.

The columbate of potassa is crystallizable, and the oxide of the metal is immediately precipitated upon the addition of an acid.

With infusion of galls	Orange precipitate,
The recently prepared oxide	Soluble in the tartaric, citric, & oxalic acids,

Neither the ferro prussiate of potassa, nor the hydrosulphurets produce any change.

The scarcity of Yttrotantalite precludes the possibility of much being known concerning the properties of this metal.

TUNGSTENUM.

The ores of this metal are chiefly found in Cornwall, and may be divided into two varieties; the one called wolfram, in which the oxide of this metal is united to iron; and the other, Tungsten, consisting of tungstic acid united to lime.

Wolfram, or the tungstate of iron, is of a dark brownish black colour: it occurs both in the crystallized and massive form, and possesses a shining uneven fracture; before the knife it gives a reddish brown streak; is considerably hard and brittle, and is a compound of the peroxyde of tungsten, or tungstic acid united with the oxide of iron and manganese, and also with silica. The specific gravity under 7.5.

Pyramidal tungston scheelium, or tungstate of lime, is found associated with tin-stone and wolfram, in Cornwall; its colour is whitish, and occurs in the massive and crystallized states; it is also found in Sweden and Saxony.

It has a shining uneven fracture, harder than fluor spar, is brittle, and of specific gravity 6.0: its component parts are tungstic acid united to lime and silica, and sometimes with iron and manganese.

The specific gravity of pure tungstenum is 17.5

Before the blow-pipe the ores of tungsten generally blacken, but are not reducible.

With borax, salt of phosphorus, and soda, they run into a glass, varying in tint according to the quantity of iron contained. The pure oxide gives on the platina wire, with salt of phosphorus, and, before the reducing flame, a fine blue glass; soda, in a similar manner, a yellow ore which becomes opake on cooling, but on charcoal a grey metallic scoria of reduced metal.

Tests.

The solutions of tungsten give with

Alkalies, caustic or carbonated	White precipitates,
Prussiate of Potassa	Dirty yellow,

Tincture galls	Brownish red,
Sulphuretted hydrogen	No precipitate.

As tungstenum has not as yet been applied to any general use, the assay of its ores may be taken from the analysis.

Analysis.

Process 1.—Wolfram may be analysed by first reducing a portion to a very fine powder, placing it in a mattrass or flask, and digesting with thrice its weight of muriatic acid; when cold, pour the whole on a filter, and wash the residue in a small quantity of water.

2.—Digest the residue in process 1, in two or three parts of strong caustic ammonia, until this alkali ceases to take up any more; wash the residue and add the washings to the ammoniacal solutions; repeat these two processes, until every thing except the silex is dissolved.

3.—Mix together the ammoniacal solutions, and evaporate to dryness; transfer the residue into a clean crucible, and apply heat until

it assumes a yellow colour: it is now pure oxide of tungstenum.

4.—The muriatic solutions containing iron and manganese having been mixed together, a small quantity of sulphuric acid is to be added, and the whole evaporated to dryness.

5.—The residue in process 4 is to be dissolved in distilled water, and the oxide of iron precipitated by the addition of caustic ammonia in considerable excess, and filtering immediately through a piece of fine gauze, ready prepared for the purpose.

6.—The ammoniacal solution is then to be evaporated to dryness and heated, which will drive off the adhering ammonia, and leave the oxide of manganese behind.

Tungstate of Lime.

The analysis of this variety, supposing it to consist of tungstic acid, lime, and silica.

Process 1.—Digest a given weight of the powdered ore alternately in hot nitric acid and ammonia, as in the analysis of wolfram. The nitric solutions will contain the lime; the ammoniacal, the tungstic acid.

2.—The nitric solution should be saturated with ammonia; if any precipitate, it will be the oxide of tungstenum, and is therefore to be added to the after produce of the ammoniacal solution; after this the lime may be thrown down either with carbonate or sulphate of soda added in excess and gently heated, we have resulting, either carbonate or sulphate of lime, from either of which the equivalent in lime may be readily estimated.

The weight of the silica which has been insoluble should now be taken; the ammoniacal solutions treated, as in the preceding analysis, and the whole finished by taking the sum of the weights of the different ingredients. Should iron or manganese be present in any instance, they may be worked as in wolfram.

Tungstenum is a hard brittle metal of an iron grey colour, difficult of fusion, and easily converted into a yellow oxide by the joint action of heat and air; from its scarcity it has not been applied to any extent in the arts. The peroxyde was found to give considerable permanence to vegetable colours.

CHROMIUM.

This metal owes its discovery to Vauquelin, who obtained it by intensely heating its oxide with charcoal; it occurs, combined with oxygen, under the form of a green incrustation, in the department of the Rhone, in France; combined with iron, under the name of chromate of this metal, in certain parts of America, France, and Siberia, and lately of very fine quality, and in large masses in the Hebrides; also in combination with lead, a mineral of a fine yellow colour but of rare occurrence, in the Uralian mountains in Siberia: we shall therefore consider them in the following order—

Native protoxyde of Chrome	Chromium and oxygen,
Chromate of iron	Chromic acid and iron,
——— lead	——— lead,

in the incrusting, chrystallized, and massive forms. Their specific gravity varies from 5 to 6.5

Action of the blow-pipe.

Before the reducing flame of the blow-pipe the pure oxide *per se* is unchanged; with borax it fuses into an emerald green glass, when acted upon by the exterior flame this fine tint changes to a yellowish brown, but on cooling again regains part of its original hue; on the charcoal support it is not reducible to the metallic state.

Tests.

The solutions of Chromium are readily distinguished by the fine yellow precipitate which falls on the addition of nitrate of lead, commonly called chrome yellow; also with

Nitrate of Mercury	Rich cinnabar precipitate.
——— Silver	Carmine, changing to purple,
——— Copper	Chesnut red, do.

Assay.

Process 1. — In describing an assay of this mineral, it is generally sufficient if we ascertain the quantity of oxide contained, without proceeding to the fusion of the metal, an operation of some little difficulty without the aid of an excellent blast furnace; to this effect, first reduce a known portion to a very fine powder, mix it with half its weight of nitre and expose the mixture to a cherry red heat for an hour, or until the whole of the nitrous gas is driven off; the mass now consists of the iron in the state of an oxide and chromate of potassa, dissolve out the latter with hot water, and separate the oxide of iron by a linen filter; dilute sulphuric acid now dropped into the solution should give no extrication of nitrous fumes, if this is the case a quantity of undecomposed nitre still remains, and very likely of chromic acid; should the latter not be the case, the former is of no consequence in an assay, but if any chromate of iron remains undecomposed it must be fused in a similar

manner with a fresh portion of the salt, and dissolved out as before; add all the clear liquors together.

2.—Saturate any excess of alkali there may be in the solution with nitric acid, which generally throws down some earthy matter; filter and pour in neutral nitrate of mercury until no further precipitation takes place; throw the whole on a paper filter, collect and dry.

3.—The red chromate of mercury thus obtained is to be placed in a retort or muffle under a chimney; when by moderate ignition the mercury will be expelled, leaving the green protoxyde behind; the lower the heat and the longer it is continued, in general, the finer is the colour of the oxide.

Analysis of the chromate of lead.

Sufficient having been said under the assay of the chromate of iron to enable any person to make an analysis of that variety. The chromate of lead may now be examined; if, however, any difficulty should arise in the method to be pursued with the earth contained, of which there may be both alumina

and lime, besides silica, the reader may refer to those substances as treated of in the after part of this work.

There are two ways of determining the composition of the chromate of lead, either of which are easily affected.

Process 1.—A given weight of the powdered ore having been taken, put it into a clean iron or unglazed earthen vessel, with three or four parts of the bicarbonate of potassa dissolved in water, and boil it over a gentle fire until the chromate of lead is wholly decomposed into carbonate of lead and chromate of potassa, pour the whole on a filter, well wash and dry the residue; should any yellowness still remain, the powder must be again treated as before.

2.—The carbonate of lead being collected and dried, its quantity of metal may be ascertained by the scale, or reduced by fusion with charcoal or black flux.

3.—The chromate of potassa, in solution, should be slightly acidulated with nitric acid, and muriate of barya added until no further precipitate is given; collect this chromate of barya on a filter, and wash with a little water.

4.—The salt obtained in process 3 is to be digested in such a quantity of dilute nitric acid as is just sufficient to dissolve it; sulphuric acid now dropped in will precipitate the barya in the state of a sulphate, leaving chromic acid in solution.

5.—The analysis may be finished by evaporating the chromic acid to dryness, and heating; chromic acid will be the result.

The ores of chromium are never worked for the metal properly so called, but for its oxide or salts containing it; of which the chromate and bichromate of potassa, the first a fine lemon yellow, and the second a red crystallized salt, are the most important; they are used in topical dyeing, and furnish the green oxide applied to porcelain painting. The chromate of lead may also be mentioned, which is prepared by adding a solution of nitrate of lead to chromate of potassa; it is a very durable pigment of a bright yellow colour; as kept in the shops it is often much adulterated with white lead.

MOLYBDENUM.

The sources from whence this metal is obtained are, first the molybdena, and secondly the molybdate of lead. The former occurs in small separate crystals of a rhomboidal shape, in Bohemia and Sweden, also in Cornwall and Scotland, the latter crystallized and in mass at Bleiberg in Cariathia; there is also another variety, the molybdena ochre; thus we have

Rhomboidal molybdena—Molybdenum and sulphur.

Molybdate of lead—Molybdenum, lead, and oxygen.

Molybdena ochre—Molybdenum and oxygen.

Molybdena occurs in rhomboidal detached crystals of a lead grey colour; they have a soft greasy feel, are easily frangible, and soil

paper if rubbed on it, leaving a bluish grey streak. Specific gravity 4.5.

Molybdate of lead, pyramidal lead, or yellow lead spar is of a wax yellow colour, and occurs in the crystallized, massive, and cellular forms. Its fracture is uneven, with a soft resinous appearance. Specific gravity, 6.5.

Molybdena ochre is of a pale yellow colour, and is found incrusting Molybdena.

The specific gravity of pure molydenum is 8.6.

If the native sulphuret of molybdenum is exposed to the action of the blow-pipe, sulphurous vapours are driven off; after which the grey powder obtained may be partially reduced on the charcoal support; with the exterior flame it is rapidly oxidated, and if put into an inclined glass tube and heated, sublimes and attaches itself to the sides in the form of a white powder. With borax and the outer flame the oxide fuses into a colourless glass, which when urged by the reducing flame becomes brown; the white or peroxyde having by this means been brought to the state of protoxyde.

Tests.

Molybdic acid forms soluble salts with soda, potassa, and ammonia; the two first are crystallizable, the latter not. The solution of the molybdic in the sulphuric acid is of a blue colour when cold, changing to white when heated, but to blue again on cooling; when the molybdic acid is triturated with molybdenum, in a mortar, it is partially converted into molybdous acid, which is of a blue colour. The molybdates of potassa and soda give a precipitate with almost every metallic solution.

With gold	White powder.
Muriate of mercury	Ditto,
——— zinc	Ditto,
——— manganese	Ditto,
——— tin	Blue,
——— copper	Ditto,
——— cobalt	Rose-coloured.

The best test is the action of heat upon it.

Assay.

The method of assaying the first variety of this ore is almost too simple to require mentioning; but as it may be wanted by some one wholly unacquainted with chemistry, it may be digested with heat in nitric acid; molybdic acid will be formed, which remains in the solution, while the sulphur is left behind; should any of the latter have been dissolved, it is to be thrown down by a few drops of nitrate of barya, taking care not to add an excess of it; the remaining solution, after filtration, is to be evaporated to dryness—molybdic acid will be the result.

Analysis of the molybdate of lead.

This variety, supposing it to consist of molybdic acid, lead, iron, and silver, may be thus treated:—

Process 1.—Having reduced a portion to fine powder, digest in moderately strong nitric acid, this will take up all but the silica; should any peroxyde of iron be thrown down,

it is to be separated by digesting in muriatic acid, and this will leave the silica pure.

2.—The solution freed from the silica, may be again decomposed by sulphate of soda, this will remove the lead in the state of a sulphate; well wash this, add the liquors together, and if any sulphur has been acidified, throw it down with nitrate of barya.

3.—To the solutions now remaining, add caustic ammonia in excess; this will remove the iron in the form of an oxide.

4.—The molybdate of ammonia now in solution, is to be evaporated to dryness, and gently heated; molybdic acid remains.

The ores of molybdena are scarce, and are only met with in commerce as mineralogical specimens; neither the metal which may be obtained by decomposing the oxide, nor its salts, have as yet been applied in the arts.

ARSENIC.

The form under which this metal is generally known, is in that of an oxide, the arsenious acid; and this is readily converted into the metallic state by fusion with half its weight of black flux in a close vessel. The arsenic now rises in the form of a brilliant metallic sublimate, possessing a crystalline surface and fracture.

Arsenic, or rather the arsenious acid, principally comes from Saxony, Bohemia, and Germany, where it is either worked directly for the market, or indirectly as a product in working cobalt, and some other ores with which it is combined in large quantities.

The ores of arsenic may be comprehended under the following varieties:—

Native arsenic,	Arsenic with a little iron.
Pharmacolite,	Arsenic, lime, oxygen.

Arsenical pyrites,	Arsenic, iron, and sulphur.
Orpiment, Realgar	Arsenic and sulphur.
White arsenic,	——— oxygen.

In the crystallized, massive, investing, and other forms.

The ores of arsenic, or rather those which contain this metal, are readily known by the strong garlic-like odour which they give off, when exposed to heat. Whether any specimen under examination is a true ore of arsenic or not, will depend upon the quantity contained. Should it have no sulphur, and the loss of weight in roasting is equal to what remains, it may be reckoned an arsenical ore; but if not it will most probably be a metal mineralized by arsenic. In laying this down as a rule, it is to be remembered that the matrix, or stony matter, should be first removed, and that sulphur was mentioned only that care should be taken that loss in weight by the roasting is not attributed wholly to arsenic, when sulphur is present.

The specific gravity of the ores of arsenic varies from 2. 5. to 6. 5.; that of the pure metal being 5. 76.

Before the reducing flame of the blow-pipe, and on charcoal, the ores of arsenic readily give off this metal in the state of white fumes, the protoxyde. The only preparation of this substance which is at all fixed, is the arsenic acid, or peroxyde; and this is readily decomposed by heat and charcoal, accompanied by its peculiar characteristic smell.

Tests for.

Metallic arsenic is readily soluble in nitro-muriatic acid, from which solution the chief part may be again separated in the form of an oxide, by alkalies; and these latter, when in excess, may be made to redissolve the whole by an increased temperature: it is necessary to state this, as two different salts result, viz.:—the arsenites and arseniates, and when a test is applied to the solutions of the one, it will sometimes indicate differently to those of the other.

The arsenite of potassa gives with—

Hydro sulphuret of ammonia,	White precipitate.
Nitrate of silver,	—— changing to brown.
Proto nitrate of mercury,	Grey.
Per nitrate ditto,	White.
Hydriodic acid,	White oxide.
Nitrate lead	White.
——— nickel	Pale green.
——— copper,	Apple ditto.
——— uranium,	Yellow ditto.
Proto and per muriate of tin,	White.
Sulphate of zinc,	Ditto.

The arseniate of potassa—

Proto muriate of tin,	White.
Permuriate,	No precipitate.
Nitrate of lead,	White.
——— silver,	Reddish ditto.
——— uranium,	Straw colour.

Many of the tests indicate the same change with either salts..

Assay.

The assay of the ores of arsenic will vary a little with the substance in combination; it may, however, generally be effected by simply mixing the powdered ore with charcoal, or other carbonaceous matter, in a subliming vessel, gradually raised to redness; when the fumes cease to arise, the vessel may be suffered to cool, and the sublimed arsenic now in the metallic state, collected from the head of the vessel. If care has been taken to condense the whole of the fumes by keeping the receiver sufficiently cool, the product obtained will indicate pretty accurately the quantity originally contained. It may also be estimated by the processes 1 and 2 of the following analysis:—

Analysis of pharmacolite, the native arseniate of lime.

Process 1.—To 100 grains reduced to perfect dryness and to fine powder, add a suffi-

cient quantity of nitric acid, assisted by heat to dissolve every thing but the silex, which is to be well washed, and collected on a filter.

2.—The clear solution, to which the washings of the last precipitate have been added, is to be evaporated to one half, to drive off any very great excess of acid there may be, and acetate of lead dropped in, until no further precipitation of arseniate of lead takes place; this precipitate is to be collected, washed, dried and estimated.

3.—The nitrate of lime now remaining dissolved, decompose by sulphate of soda, sulphate of lime will fall; if any iron is contained in the ore, it may now be precipitated by ammonia, and reduced as before.

Arsenical Pyrites.

This mineral being generally composed of three substances, viz. arsenic, iron, and sulphur, may be thus analysed:—

Process 1.—Digest a portion of the pounded ore in dilute nitric acid until every thing soluble is taken up, the residue will be sulphur and silex, and this after being well washed, dried, and weighed, is to be decom-

posed by heat; the loss will, on re-weighing, indicate the quantity of sulphur.

2.—The washings of the residue, after digesting in the acid, having been added to the decanted solution, evaporate nearly to dryness, mix this with an equal bulk of charcoal powder; place the whole in an egg-shaped crucible, and apply heat: the arsenic will be volatilized.

3.—The iron and charcoal now remaining, may be separated by placing the mixture in a flat vessel or crucible support, and applying a red heat, the first will remain, while the last will be burnt off: the difference in weight will indicate the quantity of arsenic expelled.

The analysis may also be varied by adding ammonia to the solutions after the separation of the sulphur, which will precipitate the oxyde of iron; and the arseniate of ammonia may be decomposed by heat.

Reduction.

The method of reducing the ores of arsenics on the large scale, as adopted in Bohemia, is similar to the following:—

A quantity of impure oxide, as collected

from the roasting of the arsenical or cobalt ores, and which is condensed in large flues, or chambers connected with the chimney of the furnace, is put into large square cast iron vessels furnished with conical heads.

A sufficient number of these being set in a long furnace, heat is applied, and when red hot, 15 or 20 pounds weight of the impure oxide of arsenic is ladled in, which, after it has melted, sublimes into the head of the vessel, a certain time having elapsed, the period of which the workmen ascertain by practice, another portion of ore is ladled in, and so on till a sufficient quantity to form a thick cake inside the head has been added, when the fire is suffered to go out, and the sublimed oxide of arsenic afterwards detached by a hammer; it is now purified, is white, brittle, and semi-transparent; but becomes opake, and of a milky white, by keeping.

Arsenic is one of the least valuable of the metals; with sulphur it forms two compounds, occasionally employed as colours, viz.—orpiment and realgar, a yellow and red paint; but from the dangerous effects often produced, by working with all arsenical prepara-

tions, it would perhaps have been of advantage if they had never been used; a green colour is also afforded by adding a solution of arseniate of potassa to sulphate of copper, and called, from the inventor, Scheele's green.

TELLURIUM.

The ores of tellurium come from Pensylvania under the name of graphic gold ore, although but a very small portion of this latter metal is to be found in them; there are three varieties, viz.—

Hexhahedral, or native tellurium—Tellurium with a little iron and gold.

Prismatic black tellurium—Tellurium, lead, gold, sulphur, copper and silver.

Prismatic gold glance—Tellurium, gold, and silver.

They are found crystallized in leaves, massive, and disseminated.

The ores of tellurium may be readily distinguished by their peculiar pungent odour when heated, resembling that of horse raddish. The first variety, which is very poor in gold, is as fusible as lead, but hard and brittle; its fracture is shining and metallic; specific gravity a little exceeding 6.0. It occurs in Norway, and at Facebay in Transilvania.

Black tellurium, is of a dark lead grey passing into iron black, and often contains as much as 10 per cent. of gold; it sometimes occurs in flakes, which in flexibility resemble talk.—It is easily fused. Specific gravity 7.2.

Prismatic gold glance, or Tellurium, is the richest variety of the graphic gold ores, sometimes containing 30 per cent. of this valuable metal; it is either of a steel grey, or silver white colour; hard, brittle, splendent, and metallic; with a fine grained uneven fracture. Specific gravity 5.7. It is found in a porphyry bed at Naygag in Pensylvania,

Most of the ores of tellurium have a very peculiar appearance; from the arrangement of their parts a resemblance to writing is vi-

sible on the surface, whence its name Graphic Ore.

The specific gravity of pure tellurium is 6.1; it crystallizes like bismuth after fusion, and much resembles antimony in appearance, but from which it is readily distinguished as before stated.

Before the blow-pipe the ores of tellurium give off a dense white fume, which is the oxide of the metal, and which, if inhaled, irritates the lungs and occasions violent coughing. The pure metal, on charcoal, burns with a blue flame

Tests.

Tellurium is soluble in the nitric, nitro-muriatic, and sulphuric acids; the solution with the first is permanent when diluted, but with the second a submuriate falls on the addition of distilled water; the third is of a deep blue or purple colour: on the addition of heat, the metal is precipitated white, but if diluted with water, black.

Solutions of potassa and soda	White precipitate soluble in excess of
Tincture of galls	Yellow precipitate,

Tellurium is precipitated in the metallic state by most of the metals, which have a strong affinity for oxygen—as iron, zinc, tin, &c.

Assay.

The assay of tellurium may be made in the same way as that of arsenic; being an extremely volatile substance, on the application of heat it readily sublimes from those other substances which may adhere to it; if, however, the specimen contains sulphur, part of it will rise in sublimation with the metal; it may be freed from it by solution in an acid, which will leave the sulphur, collecting in the form of an oxide, and reducing by charcoal as usual with other oxides.

Analysis.

The prismatic black tellurium, which is the most compound ore of the metal, may be

thus analyzed: supposing that by testing a solution in nitro muriatic acid, we find it to contain tellurium, lead, gold, copper, silver, and sulphur.

Process 1.—Digest a certain quantity of the finely powdered ore in pure diluted nitric acid, with the application of a gentle heat; the gold and sulphur will remain, and if any silex has been contained in the ore, that also: expose this residue, after washing, drying, and weighing it, to a low red heat; the sulphur will burn off and is thus got rid of, the quantity of which is to be estimated by weighing.

2.—Mix the residue in process 1, with twice its weight of black flux; expose it to a cherry red heat, either with a blow-pipe on charcoal, or in a crucible in the furnace; a button of gold will remain. This is to be weighed, and the difference before and after fusion, will give the quantity of silex.

3.—The acid solution, containing tellurium, lead, copper, and silver, after the washings of the gold, &c. have been added to it, is to be decomposed by muriate of soda; this will

throw down the silver: and which after well washing with hot water may be reduced in the same way as the gold.

4.—Add the washings of the precipitated silver to the remaining solution, and pour in sulphate of soda, the lead will be precipitated; its quantity of metal is to be ascertained either by calculation or reduction.

5.—To the liquors now remaining, add a solution of potassa, the copper will be precipitated along with the tellurium; they are separated by a still further addition of the alkaline liquor, which re-dissolves the latter; collect, &c.

6.—The tellurium, now alone in solution, is to be thrown down in the state of an oxide, by saturating the liquor with muriatic acid.

Neither tellurium nor its salts have as yet been applied in the arts. The reduction of the ores in the large way, if worked for this metal, would be very similar to those of arsenic; and if for the gold they contain, the tellurium would be first driven off by heat, and the residue submitted to cupellation and quartation, if necessary.

SELENIUM.

This substance was first examined by Berzelius, who obtained it from a native sulphuret of iron found at Fahlun, which is worked for the sulphur it contains for the after manufacture of sulphuric acid. At the bottom of the leaden chambers which are used in this process, a deposit of a reddish colour was found, which was ascertained to consist of sulphur and a peculiar substance to which the name of selenium was given.

Selenium, when pure, is of a deep brown colour, possessing a metallic lustre; its fracture is lead coloured and glossy; it fuses at 220°, and if slowly cooled, assumes a crystalline texture; when heated in a retort, it sublimes in the form of a deep yellow vapour, which is again condensed in the form of black drops in the receiver. When warmed it is sufficiently soft to be kneaded by the fingers, and may be drawn out into threads; it is a non-conducter of heat and electricity, pos-

sessing a specific gravity of 4.3; before the blow-pipe it readily sublimes, giving out a strong disagreeable odour, similar to horse-radish, at the same time tinging the flame of a light blue colour.

Tests for selenium.

The best tests for selenium are the peculiar smell of its oxide when heated, its extreme volatility and its forming a deep red powder.

Analysis.

The following is the analysis of an ore supposed to contain tellurium, as examined by Berzelius:—

Process 1.—One hundred parts of the mineral previously reduced to fine powder, were digested in nitric acid, the solution diluted with boiling water and filtered, what remained, was the matrix of the ore.

2.—Common salt added to the clear liquor threw down a white precipitate of chloride of silver, which after collecting on a filter, well

washing and drying, gave, by computation, the quantity of silver contained.

3.—The solution was now decomposed by passing through it a stream of sulphuretted hydrogen, the precipitate collected, redissolved in nitro-muriatic acid, and the solution concentrated until the nitric acid was entirely decomposed; it was then diluted with water, and sulphate of ammonia added, when a deep cinnabar red precipitate was thrown down; to collect the last portions of which, the liquid was afterwards boiled, adding from time to time small quantities of sulphate of ammonia; when the whole was thus obtained, it was heated nearly to fusion, and weighed.

4.—The remaining solution after boiling, was decomposed by carbonate of potassa, which precipitated the principal part of the copper, in the state of a carbonate; the last portions were obtained by acidifying the liquor with muriatic acid, and immersing a clean plate of iron.

5.—The liquid in process 2, through which sulphuretted hydrogen had been passed, was heated to drive off the excess of the gas, after which it was mixed with caustic ammonia,

which threw down a yellowish precipitate composed of oxide of iron, combined with a little alumina.

6.—The remaining solution was mixed with subcarbonate of potassa in excess, and evaporated to dryness. The saline mass when redissolved in water, left a white earth, which upon being digested with sulphuric acid effervesced, and by evaporation deposited silica.

Selenium has not been applied to any use, it does not appear to possess much right to a rank amongst the metals; but as it has a metallic appearance, and combines with two distinct proportions of oxygen, it has been placed by some chemists in this class of bodies. Its discoverer seems to consider it as intermediate between sulphur and tellurium. This substance is but little known.

CERIUM.

This newly discovered metal is obtained in the state of an oxide from several minerals found in Sweden and Greenland. The following are the varieties:—

Cerite Allanite	} Oxide of cerium, with iron, and silica.
Orthite Pyrorthite	} Oxide of cerium, iron, manganese, and yttria.

Yttrocerite—sub and dentofluate of cerium, fluate of cerium and Yttria—Cerium and fluoric acid.

Cerite is of a red colour with a brownish tinge; its fracture is splintery, has a resinous lustre, and is sufficiently hard to strike fire with a steel: reduced to powder and exposed to the action of the blow-pipe, the colour changes to yellow. Specific gravity 4.9.

Tests.

There are two oxides of cerium, the white or protoxide, and the yellow or peroxide; with the acids they both form crystalizable salts, the first are white, the second yellow; they have a sweet taste, and their solutions are not affected by sulphuretted hydrogen. They give with

Oxalic acid, oxalate of ammonia and ferro prussiate of potassa } White precipitates.

Cerite may be analysed by fluxing the pounded ore with three times its weight of potassa, dissolving out the silicate of potassa formed, and treating the residue with muriatic acid. The muriate of cerium formed is to be decomposed by oxalic acid, which throws down a white salt, and which, upon exposure to heat leaves oxide of cerium behind. The metallic base of this oxide will probably be obtained, with those of some other substances to be found under the head of Metalloyds: the other varieties may be treated in a similar manner.

TITANIUM.

The ores of this metal are found chiefly in Cornwall and various parts of Scotland, the varieties may be stated as follows:

Titanite, anatase—Titanium and oxygen.
Nigrine, menaccanite—Titanium, oxygen, iron, and manganese.
Iserine—Titanium, oxygen, iron, uranium
Sphene—Titanium, oxygen, silex, and lime.

These ores are found under the various forms of crystallized, amorphous, reticulated, and massive; and occur, besides the localities already mentioned, in Switzerland, Oysans, in France, Bavaria, and Norway. Their colour varies from yellow and red to iron black; harder than apatite, and brittle. Their specific gravity seldom exceeds 4.0.

Before the blow-pipe the ores of titanium are difficultly fusible into a slag of a deep brown or black colour, and are often at-

tractible by the magnet. The pure oxide alone, is not affected, but with the addition of a sufficient quantity of borax on the platina support, it readily fuses into a transparent colourless glass; if the proportion of oxide is increased, the fused mass, upon cooling, becomes opake and milky; with the reducing flame, on charcoal, it assumes a deep yellow, changing to dark blue when cold: with salt of phosphorus, in a similar manner, the mass is yellow whilst in fusion, changing to a violet when cold.

The salts of titanium are colourless.

With alkalies	White precipitate,
Hydro sulph. ammonia, and ferro prussiate of potassa	Green ditto,
Infusion of galls	Brownish red ditto.

Analysis of Titanite.

The assay or analysis of titanite is easily effected, supposing it to consist of the oxides of titanium and iron, silica, and lime.

PROCESS 1.—Into a clean silver crucible, capable of holding from three to four ounces, put one hundred grains of the finely divided ore; pour upon it a solution of caustic potassa, containing three or four times the weight of dry salt, of that of the mineral taken; boil gently down to dryness; place on the cover and submit to a low red heat for an hour, or until the whole of the silica is dissolved; separate the mass so formed with hot water; pour it into an evaporating dish; supersaturate with muriatic acid, and boil down to dryness; pour upon this fresh diluted acid; apply a gentle heat, occasionally stirring, and throw the whole on a filter,—what remains is silica.

2.—The remaining solution in process 1, is to be decomposed by caustic ammonia, which will precipitate the oxides of titanium and iron, these are to be collected, washed, and dried, mixed with a little muriate of ammonia, and projected into a red hot crucible, what remains should be of a white colour, and is then, pure oxide of titanium; if the whole of the iron however, is not removed by once treating with muriate of ammonia, this

operation must be repeated. The loss in weight will give the oxide of iron contained.

3.—The supernatant liquor, now containing lime only, may be decomposed by saturation with muriatic acid, adding to it bicarbonate of potassa and boiling, carbonate of lime will fall.

Analysis of Menachanite.

This variety, found at Menachan in Cornwall, and also in Bavaria, generally contains besides the substances mentioned in the last analysis, a small per centage of manganese; to separate this, the processes 1 and 2 in the preceeding analysis need not be varied.

3.—The remaining solution, containing lime and manganese, may be decomposed by oxalic acid; the lime will fall.

4.—After the separation of the oxalate of lime, the manganese is to be thrown down by a solution of carbonate of potassa, and the precipitate collected and dried.

The other varieties of the titanium ore are to be analysed in a similar manner.

The ores of titanium are rather scarce, and

may be at present considered as unimportant, no use having as yet been found for the oxides of this metal, the reduction of which to the reguline state, is an operation of great difficulty. Lampadius states it to be of a bright copper colour, and that he reduced the oxide by exposing it to a strong heat with charcoal powder.

URANIUM.

The ores of uranium are found chiefly in Bohemia, Saxony, and Cornwall, and may be divided into

Uran Ochre, Indivisible uranium, or pitch ore Uranite, or uran mica	Oxides of uranium with lead, copper, and iron, together with silica & sulph.

The colour of the first variety is lemon or straw yellow, and is found incrusting the

surface of pitch ore; lustre glimmering, soft. Specific gravity 3.15.

The second variety, or pitch ore, is generally black and massive, shining, and somewhat hard and brittle. Specific gravity 6.5.

Uranite is of a dark green colour, and occurs crystallized or in thin flakes; easily frangible. Specific gravity 3.0 to 3.4.

Before the blow-pipe, when mixed with borax, these ores generally run into a dull yellow glass.

The peroxide alone, blackens and passes to the state of protoxide; fused with microcosmic salt in the spoon, it forms a transparent yellow glass by the exterior flame, and a fine green with the inner.

Tests for

The salts of uranium are yellow or greenish yellow.

Alkalies	Yellow precipitate,
Hydro. sulph. of ammonia	Dark brown,
Ferrocyanate of potassa	Fine brown,
Hydriodic acid	Reddish yellow.

Analysis.

The variety called pitch ore may be thus analyzed:—on trial, I find contained oxide of uranium, oxides of iron and copper, sulphur, lead, and silica.

Process 1.—Digest a given quantity of the finely powdered ore with four or five of nitric acid, rather dilute, until all action ceases, and until a further addition of fresh acid produces no effect; sulphur and silica will be left behind, which may be separated by heat, and their weights estimated.

2.—To the clear solution in process 1, may be added sulphate of soda, which will precipitate the lead in the form of a sulphate; collect, dry, and estimate the quantity of lead contained by the scale of equivalents.

3.—Decompose the solution after the washings of precipitate 2, have been added, with caustic potassa. Digest the precipitate thus obtained in caustic ammonia; the copper will be dissolved, and may be obtained in the metallic state by slightly supersaturating the ammonia with an acid, and immersing a piece of clean iron or zinc.

4.—The oxides of uranium and iron remaining are to be dissolved in fresh acid; the solution precipitated with caustic ammonia; and subsequently treated as in process 2 of the titanium ore; or the mixed oxides may be boiled in a considerable quantity of a solution of the bicarbonate of potassa, which will take up the oxide of uranium, and leave the iron; to obtain the first supersaturate the solution with muriatic acid, and precipitate with caustic ammonia; or the iron may be precipitated by a cylinder of zinc, and the mixed oxides of uranium and zinc obtained by precipitation with caustic potassa; treated with pure ammonia, which will dissolve the latter and leave the former.

Uranium is to be obtained by heating the oxide intensely with charcoal powder; it is a brittle metal, of a grey colour, and has not as yet been applied to any useful purpose, which arises probably from the scarcity of its ores, it appearing capable of yielding several colours useful to the artist.

COBALT.

By far the greatest part of the cobalt which is seen in this country comes from the Saxon mines, under the form of zaffre, a very impure substance, consisting chiefly of siliceous matter, ground up and containing a small portion of the oxide of this metal, together with a considerable quantity of arsenic, and sometimes nickel and bismuth from the imperfect manner in which it has been purified. The cobalt ores are also found in Cornwall, and will most probably be soon discovered in various parts of this kingdom.

The ores of cobalt may be divided into four species, each of which has its varieties.

Cobalt pyrites	Cobalt, arsenic and sulphur, and often copper and iron,
Red cobalt	Cobalt, arsenic acid, and water,
Cobalt ochre	Oxides of cobalt and iron with arsenic.
Sulphate of cobalt	Oxide of cobalt, sulphuric acid, & water,

The colour of the different cobalt ores are silver and tin white, steel grey, straw yellow, flesh red, crimson, brown, and black; they are mostly either soft or brittle, and give a grey streak with the point of the knife; they occur in the crystallized and massive state; their specific gravity varies from 2.4 to 6.6: when rubbed together they usually emit an arsenical odour.

Before the blow-pipe the ores of cobalt are easily distinguishable—first, giving off sulphur and arsenic, and, on the addition of borax, running into a fine blue glass. The colouring property is so intense, that a very small portion must be added, otherwise the colour of the globule will appear black; one grain of the oxide producing a deep tinge with two hundred of glass.

With salt of phosphorus the effect is very similar.

Tests.

The solutions of the salts of cobalt are either of a red, green, or blue colour, according to the quantity of metal contained.

Potassa and soda	Blue precipitate,
Ammonia	Blue ditto, soluble in excess of
Ferro prussiate of potassa	Green precipitate,
Hydrosulphuret of ammonia	Black,
Arseniates, carbonates and phosphates	Red precipitate,

Analysis.

The cobalt ores may be assayed or analysed in the following manner:—

Process 1.—Mix one part of the finely divided ore with three of nitre in a crucible, and submit to a red heat for half an hour; dissolve out the arseniate of potassa thus formed and treat the residue again in the same manner; after which digest the residue then remaining in dilute nitric acid, and filter.

2.—The nitric solution may now be evaporated, to drive off any great excess of acid there may be in the solution, and largely

diluted with water—this will separate the bismuth.

3.—Immerse into the solution from which the bismuth has been thrown down a plate of iron of known weight, this will separate the copper—evaporate the remaining liquor to dryness.

4.—The dry mass in process 3, is to be digested in caustic ammonia, which leaves the iron and dissolves the cobalt and nickel.

5.—Drive off the excess of ammonia in process 4, by heat; taking care not to continue the evaporation so as to produce any precipitate. Add caustic potassa, and throw the whole quickly on a filter—by this operation nickel is separated.

6.—Boil the clear liquor remaining—oxide of cobalt will fall.

7.—Mix the oxide obtained in process 5, with charcoal powder, and reduce in a crucible with a good heat; a button of cobalt will be thus obtained of a bluish grey colour, which, upon exposure to the air turns reddish grey; it is brittle, of difficult fusibility, and of specific gravity 7.7

Note.—For the analysis of the earthy mat-

ter dissolved by the fluxing process, see the article Silex.

Metallic cobalt is not used, but its oxide is, very largely; both *per se* and fluxed into a glass, which when ground up constitutes the different qualities of smalts and azure found in the markets.

The method of working the ore for the manufacture of smalts is simple, and may be performed as follows:

Take any quantity of cobalt ore, break it into small pieces, and roast it in a furnace constructed for the purpose until the arsenical fumes cease to arise; when cold it may be removed, ground to coarse powder, and again roasted; this will drive off nearly the whole of the arsenic, which is retained with great tenacity.

An assay should now be made to estimate the quantity of cobalt contained, as, on the strength of it will depend the quantity of siliceous matter to be added; this being ascertained, the roasted ore is to be mixed with the requisite quantity of pot or pearl ashes and ground flints, the mixture put into large

clay crucibles and fluxed with a strong heat for ten or twelve hours, at the end of which the glass will be perfect and of a fine blue colour. It is to be ladled out and run into water to make it friable. When ground to powder it is denominated smalts, or azure, according to its degree of fineness. At the bottom of the crucible will remain the bismuth and nickel, the separation of which is easily affected by the low degree of heat required for the fusion of the former to that of the latter.

BISMUTH.

The ores of bismuth are of comparatively rare occurrence, the chief part of the metal which is in commerce coming from the smalt

makers as mentioned in the preceding article, they may, however, be divided into

Native bismuth	
Sulphuret of bismuth	Bismuth and sulphur,
Bismuth ochre	——————— oxygen,
Carbonate bismuth	Bismuth, carbonic acid, oxide of iron, and water.

The above are found chiefly in Cornwall in veins, in mica slate, also in Saxony and Siberia. Their colour varies from silver white to dark lead grey, and straw yellow. The specific gravity of native bismuth is often as high as 9. the other varieties vary from 4. to 6.5— harder than gypsum.

Before the blow-pipe *per se* they are easily fused, and on charcoal they are reduced; with borax the pure oxide runs into a grey glass, and, by continuing the heat the metal is reduced and volatilized.

Tests for

The solutions of bismuth are white.—Water throws down a fine white oxide.

Gallic acid	Greenish yellow,
Ferrocyanate of potassa	Light yellow,
Alkalie	White precipitate.

Assay.

The assay of the ores of bismuth may be readily effected by digesting a portion reduced to fine powder in nitric acid, filtering, washing the filter with a little dilute acid, mixing the solutions together and throwing them into eight or nine times the bulk of distilled water; a white oxide falls, which is easily reduced with a little black flux or charcoal powder to the reguline state. The heat employed should not be more than sufficient for the reduction, otherwise a part will sublime, and be thus lost; the crucible should also be well covered.

Analysis.

Supposing the ore to be found on trial to contain bismuth, lead, arsenic and iron, besides sulphur and silica—

Process 1.—Digest a determinate quantit

(reduced as usual to fine powder) repeatedly in nitric acid, until no more is dissolved by the addition of fresh acid; silex and sulphur will remain, which may be collected on a filter, washed with dilute acid, dried, weighed, and separated by heat.

2.—The clear liquors having been added together, largely dilute with water as in the assay; the bismuth will fall, and is to be reduced as before mentioned.

3.—A solution of sulphate of soda may now be added until the whole of the lead, in the state of an insoluble heavy white precipitate, has fallen; collect on a filter, &c.

4.—To the remaining solutions add caustic ammonia in excess, this will precipitate a brown powder, which is the oxide of iron, (whilst the residual liquor will have assumed a fine blue tint,) separate by the filter and wash the oxide of iron with more ammonia; dry and reduce to the magnetic state by mixing it with linseed oil in a crucible, and applying a furnace heat.

5.—Having mixed together the ammoniacal solutions, slightly supersaturate with any acid,

and immerse a bar of iron or zinc: the copper will be obtained in the metallic form.

Reduction.

Bismuth being extremely fusible, the ore may be readily worked by throwing it, broken into fragments, on ignited coals; the sulphur will burn off at the same time that the metal is reduced and runs to the bottom of the furnace, from whence it is occasionally withdrawn by the removal of a stopper inserted for the purpose. Should silver be contained, as is sometimes the case, it may be ascertained by cupelling a portion without any further addition, bismuth being equally as well adapted for this purpose as lead, and might be more frequently used were it not for its being too expensive.

For cupelling see silver ores.

Use of bismuth.

Bismuth is chiefly employed for the purposes of soldering, its alloys with some of the other

metals being even more fusible than itself: The oxide of bismuth, as prepared by its precipitation from the nitric acid by water, is used occasionally as a cosmetic; when a little muriatic acid is added to the nitric solution, and the precipitate obtained is but slightly washed, it appears composed of small glittering scales, and in this state is sold by perfumers under the name of pearl powder; the application of such substances, however, very soon render their further use absolutely necessary.

ANTIMONY.

This metal, when pure, is of a brilliant white, or bluish white colour, showing a radiated fracture when broken; by exposure to heat and air it is converted into a white oxide, which sublimes in vapours. Its ores are found chiefly in Saxony and the Hartz; also in Cornwall, Allemont in France, Spain,

Mexico, and Siberia. The principal varieties are—

Native antimony	Antimony with a little arsenic, silver, and iron,
Grey sulphuret of antimony	Antimony and sulphur,
Red antimony	Antimony, oxygen, and sulphur
Nickelliferous grey antimony	Antimony, arsenic, nickel and sulphur,
Antimonial ocre	Oxides of antimony with silica.
White antimony	

The ores of antimony are soft, and vary in colour from light lead to dark lead grey; their specific gravity varies from 4.4 to 6.8; they possess a metallic lustre, are brittle, and occur in the crystallized and massive forms.

Before the blow-pipe the ores of antimony are easily reduced *per se*; they emit white fumes of a sulphurous and arsenical odour, and by a continuance of the heat the metal contained is entirely dissipated in the form of

a white oxide; again reducible on charcoal to the reguline state. With borax the oxide runs into a yellowish coloured glass, which becomes much paler on cooling; and which, when saturated with metal and strongly heated by the reducing flame becomes opake from the globules of metal interspersed; with salt of phosphorus on the platina wire it forms a transparent colourless glass; with soda the effect is very similar.

Tests for

The solutions of antimony in muriatic acid are decomposed by dilution with water; a white powder (a submuriate) falling down.—

A plate of iron or zinc	Black powder of metallic antimony,
Sulphuretted hydrogen and hydrosulphurets	Orange precipitates.

Assay.

The assay of the ore may be taken from the following analysis:—

Process 1.—A portion of the ore reduced to fine powder, was digested in nitro-muriatic acid, consisting of four parts muriatic and one nitric, until every thing soluble was taken up, the residue was sulphur and silica, and this when washed and dried, was held in the flame of a spirit lamp until the blue flame had disappeared, the remainder was now pure silica, and the loss in weight sustained, gave that of the sulphur.

2.—The clear solution, in process 1, being now thrown into water, the submuriated oxide of antimony fell, which, when the whole was collected, was reduced with a little black flux to the metallic state.

3.—The remaining liquor, reduced very low by evaporation, was again thrown into water, another portion of antimony was thus obtained, which was added to the former quantity.

The solution being now tested, showed only

lead and iron, the first of which was precipitated by a solution of sulphate of soda; and the second by caustic ammonia, both of which upon treating with charcoal powder, gave the metals in the reguline state.

As some of the ores of antimony contain silver, should that be the case in any specimen hereafter tried in this way, it will be found in the first process, as an insoluble residue, mixed with the sulphur and silica; to separate it the residue may be digested in ammonia, which will take up the muriate of silver, and which may be again separated by supersaturating with muriatic acid, and immersing a plate of iron or copper.

Reduction.

The antimonial ore after it is broken into small pieces, is placed on the floor of a reverberatory furnace, and heated at first very gently to drive off the sulphur contained; after some time the metal will have changed to the state of an oxide, and this is to be again reduced to the metallic state by fusion with small coal or other carbonaceous matter.

The antimony obtained in this way, is, however, liable to many impurities; if, therefore, it is required for chemical purposes, it should be dissolved in nitro-muriatic acid, precipitated by water, mixed with twice its weight of tartar, and fused when it is pure.

Antimony is used in medicine, forming with several agents, very active compounds; it also enters into the composition of type metal as used for printing.

LEAD.

The ores of lead are very numerous, the metal being mineralized by sulphur, oxygen, molybdic, chromic, arsenic, carbonic, and muriatic acids. Lead is also found combined with other metals, in the reguline state, as well as with earths, and metallic oxides.

The ores of lead are generally found in

primitive mountains. They usually appear either metallic, or in a slight degree transparent.

Varieties.

Galena,	Lead and sulphur,
Blue lead,	
Bournonite	Lead, antimony, copper, and sulphur.
Native minium,	Lead oxygen.
Carbonate of lead,	Lead carbonic acid water.
Muriate of lead,	Lead oxygen, muriatic and carbonic acids.
Phosphate of lead,	Lead, oxygen, phosphoric and muriatic acids.
Arseniate of lead,	Lead, oxygen, arsenic and muriatic acids.
Sulphate of lead,	Lead, oxygen, sulphuric acid and water.
Molybdate of lead,	Lead, oxygen, and molybdic acid
Chromate of lead,	Lead, oxygen, and chromic acid.

Galena is generally of a colour rather bluer than that of pure lead, and occurs in cubical crystals; in its primitive form it is glossy, and soils the fingers. It generally contains, besides lead and sulphur, a portion of silver, varying from the one-twelfth to the one-three hundredth of its weight. This variety is very abundantly found in many countries, and often cantains as much as 83 per cent. of pure lead.

The next variety, or blue lead ore, is a rare mineral, found in Saxony and France; it has a slight metallic lustre, and is found massive, and crystalized, among fluor spar, quartz, &c.

Bournonite, much resembles the first variety in appearance, although its composition is somewhat different, it is often crystalized.

Native minium occurs massive, and pulverulent; it is considered as a pure oxide of lead, and is found in Yorkshire, France, Germany, &c. It occurs in clay, and sulphuret of lead, and is generally of a scarlet colour, sometimes tainted with brown or yellow.

Carbonate of lead is usually white, it occurs crystalline, massive, and fibrous; these

two latter varieties being mostly opaque; it is not very abundant, although found in many parts of the world, as it occurs but in small quantities along with other lead ores. Carbonate of lead sometimes contains carbonate of copper, which gives it a green colour; it also sometimes slightly resembles the first variety in appearance, thus exhibiting the partial convertion of carbonate into sulphuret of lead.

Muriate of lead, or horn lead, is found in Bavaria, at Matlock in Derbyshire, &c. It is of a yellowish green colour, and occurs in slightly transparent pyramidical crystals.

Phosphate of lead, is found in Saxony, and some other places. It is of a greenish-yellowish, or brownish colour; sometimes contains arsenic, and occurs in transparent six sided prismatic crystals.

Arseniate of lead is met with in England, France, and Germany, usually in the form of six sided crystals, or in fibres; it has a resinous lustre, and varies in colour from a yellow to a light green. It is found with sulphuret of lead, fluate of lime, and quartz; its crystals are generally transparent.

Sulphate of lead occurs crystalized in various forms. It is found in Cornwall, and many other parts of Great Britain; its crystals are usually transparent and colourless, or somewhat of a smokey colour; it is often accompanied by sulphuret of lead.

Molybdate of lead occurs in Carinthia, Mexico, Saxony, &c. It is crystalized, has a resinous lustre, and colour of different shades of yellow, it varies much in form.

Chromate of lead.—(See ores of chromium.)

The sp. gr. of lead ores vary from 3. to 7.5. Those of a metallic appearance being the heaviest. Pure lead has a sp. gr. varying from 11. to 12.

The ores of lead are for the most part reduced to the reguline state on charcoal, by the action of the blow-pipe. Those of a metallic appearance being easily fused, and their arsenic and sulphur volatilized.

The pure oxide of lead, and native minium, exposed *per se* to the flame of the blow-pipe, fuse into a yellowish glass, commonly called litharge, or glass of lead. With glass of

borax they give a similar result, but the colour of the glass is not so deep.

Pure lead melts by the flame of the blow-pipe, a skin of oxide forming upon its surface.

Tests for lead.

Sulphate of soda,	White precipitate.
Ferrocyanate of potassa,	Ditto ditto.
Infusion of Galls,	Ditto ditto.
Water impregnated with sulphuretted hydrogen,	Black ditto.

Assay.

The assay of a lead ore may be accurately made by any one in the following simple manner:—Reduce a given weight to coarse powder, place it in a muffle, and apply a heat just sufficient to volatilize the arsenic and sulphur; when, upon removal from the fire, all sulphurous and arsenical odours cease to be emitted the roasting is finished. Having done this, it is to be mixed with black flux, placed in a crucible, and a little common salt thrown in;

the crucible placed in the furnace, and a good red heat applied; upon cooling a button of lead will be found, equal to the quantity contained in the ore.

If the ore assayed, is a galena, its own weight of black flux will be sufficient; if it is of a much more infusible nature, twice its weight should be used; and, in this case, one fourth its weight of charcoal powder may also be added. Particular care should be paid in the roasting of lead ores, not to fuse them, as with this precaution the expulsion of their volatile parts goes on much more rapidly.

Analysis.

Supposing an ore of lead to consist of carbonic acid, green oxide of copper, and white oxide of lead, its analysis may be performed as follows:—

Process 1.—Having put 100 grains into a Pepy's bottle, (the weight of which is previously ascertained,) pour on it, by degrees, 100 grains of nitric acid, diluted with its own weight of water, an effervescence will immediately begin, which having entirely subsided, the weight lost by the bottle, on reweighing,

shows the quantity of carbonic acid which the ore contained.

2.—The clear liquor thus obtained having been put into a cylindrical glass jar, drop in a solution of sulphate of soda, until a white powder ceases to fall; this precipitate, which is sulphate of lead, is to be washed and dried. For the quantity of lead contained, see scale of equivalents.

3.—The copper now remaining in the solution, may be obtained by immersing a plate of iron or zinc, and suffering it to remain at rest for 24 hours, the copper will thus fall in the metallic state; and if upon testing the liquor with ammonia, a brown powder only falls, without any blue tint in the residual liquor, it is a proof that the whole of the copper is thrown out of combination; should any quantity, however, still remain, the solution containing the bar is to be gently heated, when the whole will fall.

Reduction.

Lead being a plentiful metal, its reduction is not performed with such nicety as that of most of the preceding metals. Galena is the

only ore of lead found in sufficient quantities to be worked; this is first picked as free as possible from stony matter, after which, being broken up, it is roasted in large furnaces, built for the purpose, by which the sulphur and arsenic are driven off, from thence it is carried to the smelting furnace, where it is thrown in, mixed with the coals, and the fire kept up at a strong red heat by the working of large double bellows. The ore now melts, and running through the coals, is reduced, the metallic lead being afterwards let out at the bottom of the furnace, and cast into pigs.

Most of the lead met with in commerce, contains silver, the quantity having been ascertained at the smelting-house to be too small to pay the expence of working for it; but as this is not always the case, and when a sufficient quantity as about 12 or 14 ounces in the ton exists, it is separated by exposing the metal to a high heat, at the same time passing a current of air over the surface, the lead is thus oxidated and converted into litharge, while the silver remaining unchanged, is collected at the end of the process.

The litharge is afterwards reduced into

reguline lead, by melting it with coals in a close furnace.

Lead is a metal of much importance, as from its durability it is extensively used in the construction of water-pipes, as a covering for flat surfaces or tops of buildings, &c. &c. Its salts, which are poisonous, are used in medicine to form sedative external applications, and frequently not a little by the disreputable wine-merchant, to stop the process of acetous fermentation. Wine thus poisoned, may, however, be readily distinguished, a small quantity of the bi-carbonate of potassa producing a white precipitate, and sulphuretted hydrogen a black one. Pure wine will not be affected by either of these tests.

The oxide of lead enters into the composition of white glass, which it renders clearer and more fusible; it is also used in glazing common earthen vessels, hence the reason that pickles kept in common red pans become poisonous. Lead with tin, and a small quantity of some of the other metals, forms pewter; with antimony it forms the alloy of which printing types are made.

Lead is a soft metal, of a bluish white

colour, malleable and ductile, but inelastic, its specific gravity is somewhat increased by hammering.

WODANIUM.

This metal, first discovered by Lampadius, in a mineral called woodan pyrites, is of a bronze yellow colour, malleable and of sp. gr. 11.47. It possesses a hackly fracture, and is strongly attracted by the magnet. By the contact of heat and air, it is converted into a black oxide; both the metal and the oxide are readily soluble in nitric acid.

Tests for.

The solutions of the metal in acids are colourless, or slightly tinged with yellow, they give with—

Ammonia,	Blue precipitate.
Carbonated alkalies,	White ditto.

Ferrocyanate of potassa,	Grey ditto.
Bar of zinc,	Black metallic powder.

Neither the infusion of galls, the phosphates, or arseniates produce any precipitate.

Very little is known of this new metal.

COPPER.

Copper is found native, but much oftener in combination with other metals, oxygen, sulphur, and acids.

The ores are usually of a green or brownish red appearance; are found in veins, and beds in Cornwall, Staffordshire, and several other parts of Great Britain, as well as in Germany, Sweden, &c.: in France, Spain, Ireland, and Norway, copper is much less abundant; its ores occur in beds of lime-stone and granite.

Varieties.

Native copper	
Glance copper Buntkupfererz	Copper, sulphur, &c.
Copper pyrites	—— —— iron, &c.
Tenantite	—— —— —— & arsenic.
Red oxide of copper Black ditto	—— oxygen,
Blue and green carbonate of copper	—— —— carbonic acid, and water,
Chrysocolla	—— —— —— silex, &c
Dioptase	—— —— —— lime, &c.
Blue vitriol	—— —— sulphuric acid, water.
Muriate of copper	—— —— muriatic acid, water.
Phosphate of copper	—— —— phosphoric acid.
Arseniate of copper	—— —— arsenic acid, water.
Martial arseniate of copper	—— —— —— iron.

Native copper has a metallic lustre and yellowish red colour; it occurs massive, arborescent, and crystallized in various forms; it is abundant in Great Britain, but less so in France. It is usually found associated with granite or fluor spar, is flexible and malleable, generally oxidated on its surface.

Glance copper, occurs massive and crystallized; is of a grey colour, possessing a metallic lustre; it yields easily to the knife, and is usually found in primitive mountains; it contains a little iron.

Buntkupfererz differs but little from the last mentioned variety: it is of a brown colour, has an irridescent tarnish, and contains rather more iron: it is usually found accompanying it.

Copper pyrites is usually of a bronze yellow colour; possessing a metallic lustre; it is found massive, stallactitic, and chrystallized; it is one of the commonest ores of copper; and is found in veins, often accompanied by iron, pyrites, &c. &c.; it easily yields to the knife, and in general contains no more than 20 per cent. of the pure metal. Sometimes it has a beautiful irridescent tarnish, and is then called peacock copper ore.

Tennantite is of a greyish colour, and splendent; it is sometimes massive, but mostly crystallized; its streak is reddish grey; brittle, and commonly occurs in Cornwall.

Red and black oxides of copper, differ from each other but in colour; and, in that the former occurs crystalline and translucent, while the latter is pulverulent; they both yield easily to the knife, and are principally found in Cornwall.

The blue and green carbonates of copper are chiefly found on the continent, but occasionally in Cornwall; they occur massive and crystallized, the latter, (which is generally called Malachite,) possesses a silky lustre, and is often found stellated, or of a fibrous texture. They are neither of them very abundant.

Chrysocolla, is only a variety of the green carbonate of copper, which contains about 28 per cent. of silex, in other respects it is exactly similar to it.

Dioptase is an extremely rare mineral, found in Russia; it is of an emerald green colour; occurs crystallized in the Dodecahedron, and is very little known.

Blue vitriol is of an azure blue colour, sometimes with a tinge of green; it occurs massive, crystallized, pulverulent, and stalactitic; it is soluble in water, has a nauseous metallic taste, is transparent, and is found in a mine in Anglesea.

Muriate of copper is a rare mineral, occuring in small crystals resembling green sand, it often invests quartz, and is found in Peru and Chili.

Phosphate of copper is exteriorily of a greyish black colour, but, when broken, presents a green appearance; it occurs massive and crystallized; it is found in Germany; and is also a rare variety.

Of the arseniates of copper there are several varieties, differing but little in appearance; they are, generally, of a beautiful verdigrease colour, and are found crystallized in a number of different forms; they also occur massive, and are very poisonous.

The martial arseniate of copper, has a vitreous lustre, and contains some iron. This, and all the arseniates of copper, are chiefly found in Cornwall.

The specific gravity of copper ores, go-

nerally varies from 3.0 to 5.0; those of a blue or green colour being the lightest; native copper varies from 8.4 to 8.7, the pure metal being nearly the same.

Action of the Blow-pipe.

The red copper ores may be easily reduced upon charcoal by the inner flame; but if the varieties are of a black colour the reduction will be more difficult. With glass of borax, the mass assumes a green or black colour, which, upon the addition of a small quantity of charcoal, yields the revived metal. Those varieties containing sulphur and arsenic, give out white fumes, emitting sulphurous or garlic-like odours. Before the oxyhydrogen blow-pipe the metal readily burns off, tinging the flame of a beautiful green colour.

Tests for Copper.

Plate of iron	Metallic copper,
Potassa	Green precipitate,
Ammonia	A fine azure blue solution,

Ferrocyanate of potassa	A reddish brown precipitate,
Infusion of galls	Brown,
Water, impregnated with sulpuretted hydrogen	Brownish black.

Assay of Copper Ores.

As the ores of copper generally contain arsenic and sulphur, these substances must first be expelled by a gentle heat; when fumes cease to be emitted, the roasting is finished, after this, it is only necessary to mix the assay with twice its weight of black flux in a crucible, and to expose it to a bright red or white heat, which may be readily effected either by the bellows-table or the portable furnace: should the globules of revived metal not readily fall into one, a little common salt thrown in will render the flux more fluid. A button of reguline copper will be thus obtained, indicating the per centage contained in the ore.

Analysis.

The analysis of the common sulphuret of copper may be thus effected:—

Process 1.—Digest a given quantity of the ore, in fine powder, in dilute nitric acid, this will dissolve the copper, part of the sulphur, and any iron that may be contained; silex and the residue of the sulphur will remain, which, after being dried and weighed, may be separated by the flame of a spirit lamp.

2.—That portion of the sulphur which has been acidified by the nitric acid, may now be thrown down by nitrate of barya; the precipitated sulphate of barya is to be collected, dried, and the quantity of sulphur estimated and added to the quantity burnt off in process 1.

3.—Precipitate the copper from the solution by a bar of iron, suffering the whole to remain at rest for twenty-four hours, scrape the bar clean, and collect the metallic copper on a filter, wash, dry, and weigh it.

4.—Caustic ammonia, added in excess to the remaining solution, will now throw down the iron, in the state of an oxide; throw the

whole on a filter, and if the liquid that passes through is colourless, the analysis is finished, but if of a blue colour, it must be slightly acidified by any acid, a bar of iron again inserted, and the action assisted with a gentle heat; the remainder of the copper will now fall. The oxide of iron is of course to be collected, and the weight lost by the bar deducted.

Reduction.

The reduction, in the large way, of copper ores containing sulphur, is rather tedious, but at the same time it is a process of great importance, as the sulphuret of copper is one of the most abundant varieties.

The ore having been dug out of the mine, the labour of which is generally shortened by blasting with gunpowder, is first broken into small pieces, transferred to kilns, and roasted; a few ignited coals, placed in one or two places being generally sufficient, as the ore from the quantity of sulphur it contains, when once set on fire, burns of itself without further addition; when the ore ceases to

burn, which generally takes from five to six months, this part of the process is finished, and the sulphur, which is generally collected in chambers constructed for the purpose and communicating by long flues to the kiln, is removed.

The next process is to separate the metal from the matrix combined with it, to effect which, the roasted ore is removed to reverberatory furnaces, where it is sbmitted to a white heat mixed with coals, for several hours, the result of which is the copper in a metallic but very impure state. It is afterwards refined by repeated roastings, granulating in water, and fusing with a little charcoal.

In those ores of copper which contain arsenic, the sulphur is not collected, but both are dissipated by tall chimnies leading from reverberatory furnaces, and, by this method, the roasting process is much shortened, being accomplished in a few hours; the refining is afterwards conducted as in the foregoing process, or by adding about 6 per cent. of lead to the copper in a melted state, which is afterwards skimmed off after vitrifying and uniting with the impurities contained, the

process is known to be finished when upon removing a portion by a clean iron rod and plunging it in water it separates easily. Copper thus obtained, is of a red colour, tenacious, and malleable; it requires a strong heat for its fusion, when it absorbs oxygen from the air, and its surface becomes covered with a thin coat of oxide.

Uses of copper.

Copper, on account of its imperishable quality, is generally employed in the manufacture of kitchen utensils, and copper boilers, for sheathing ship's bottoms, as a circulating medium, and for alloying with gold and silver, as in certain proportions it renders these valuable metals much harder and more durable; it is also the basis of brass, pinchbeck, prince's metal, dutch gold, &c. also of two pigments called Scheele's green and verdigrease, an arseniate and acetate of the metal; its oxides are occasionally used in porcelain painting, and in fireworks.

CADMIUM.

This new metal, which owes its discovery to Mr. Stromeyer, is obtained from some of the ores of zinc, in which it exists in small quantity; owing to this circumstance neither ores nor any varieties can be mentioned,

Before the blow-pipe it immediately fuses, and volatilizes if the heat is continued; it is of a fine white colour much resembling that of tin; it is malleable, ductile, and susceptible of a good polish; by mere exposure to the air it does not easily tarnish, but if heated in contact with it, it inflames, and passes off in the form of a dense vapour, which, when collected, is the oxide of the metal, and is of a deep brown colour. When this oxide is fused with borax, it forms a transparent white glass, which on charcoal is immediately reduced.

The specific gravity of the pure metal is about 8.6.

The oxide, when subliming, has no peculiar smell.

Tests for

The solutions of cadmium in the acids, are colourless and crystallizable, possessing an acrid metallic taste,

With potassa and soda	White oxide,
Ammonia	Do. soluble in excess of
Ferrocyanate of potassa	White precipitate
Sulphuretted hydrogen	Orange yellow,
Bar of zinc	Metallic cadmium.

Process for obtaining cadmium.

For the following simple process for obtaining cadmium, we are indebted to Dr. Wollaston:—

Process 1.—Having made a strong solution of calamine or other ore of zinc, in any of the three mineral acids, immerse in it a clean plate of iron until no further precipitation takes place; filter the liquor.

2.—Into the solution now holding cadmium, but freed from the copper, lead, &c., immerse

a cylinder of zinc; the cadmium will be precipitated in a metallic state, and in a leafy form, similar to that of copper by metallic iron.

To ascertain whether an ore of zinc contains cadmium or not, Dr. Clarke recommends the application of a very gentle heat on a small portion of the ore by the blowpipe, when if this metal is present a yellow sublimate will be deposited on the support, previous to the reduction of the zinc.

TIN.

The ores of this metal are found in compatively few places; the principal and perhaps only ones are Cornwall, Gallicia, Erzgebirge in Saxony, Bohemia, Malacca, and Banca in Asia. They are peculiar to primitive rocks, generally in granite, either in veins or beds,

and are often associated with copper and iron pyrites.

The varieties are—

Tin stone	Tin, oxygen, silica, and iron,
Wood tin	Oxides of tin and iron,
Tin pyrites, or bell-metal ore	Tin, copper, sulphur and iron.

Tin stone occurs in the crystallized, massive, and desseminated forms, it is hard and brittle, of a dark brown colour, giving a greyish streak with the point of the knife; when broken it exhibits an uneven surface. Specific gravity from 6.5 to 7.

Wood tin is of a light brown colour, easily frangible, softer than the preceding variety, and when broke or cut often resembles in appearance the grain of wood, or root of a tree. The specific gravity of this variety is nearly the same as the other, it is an oxide of tin, with less foreign matter than either the preceding or the following.

Tin pyrites, a native mixed sulphuret of tin, copper, and iron, varies in colour from grey

to brass yellow; it has a shining metallic lustre, and a specific gravity seldom exceeding 4.5 it is therefore the lightest of the tin ores.

Before the blow-pipe the ores of tin melt, and are either reduced or run into a dark slag. The protoxide of the metal burns, absorbing a fresh portion of oxygen, and turning to the state of peroxide: this latter may be reduced with the addition of soda on the charcoal support, to the metallic state. With borax and salt of phosphorus the peroxide in small quantities forms colourless transparent glasses, becoming opake when added in excess.

Tests for

The salts of tin are generally white, when digested, in diluto nitric acid with heat a white peroxide falls. With solutions holding the metal in the state of protoxide

Muriate of gold gives a	Purple precipitate
——— platina	Orange ditto,
Ferrocyanate of potassa	White ditto,
Per chloride of mercury	Black,
Plate of lead	Metallic Tin.

The specific gravity of pure tin is 7.29 possessing a silvery lustre and crystalline appearance, emitting a crackling noise when bent.

Assay.

The assay of the ores of tin, in the dry way, is simple and easily performed—Having reduced a portion of the ore to powder, place it in a crucible, or on the slab of a muffle, and expose it to a low red heat, if sulphur or arsenic is contained it will be thus got rid of. The residue when mixed with a little charcoal and linseed oil in a well-closed crucible, is to be subjected to a bright red heat, by which it will be reduced to the metallic state.

The assay or analysis of the ores of tin in the moist way is effected as follows:

Process 1.—After reducing a portion of the ore to the state of a very fine powder, mix it with a solution of caustic potassa, containing five or six times the weight of the ore employed, of dry alkali, boil down to dryness in a silver crucible, and subject the residue to a low red heat for half an hour; the grey mass now remaining is to be digested in water,

and any insoluble matter that may still remain is to be again mixed with more alkali, and the process just given repeated, if any thing now remain muriatic acid will take it up.

2.—The alkaline solutions are first to be supersaturated with muriatic acid and evaporated nearly to dryness, upon digestion of the mass in hot water the silica will remain.

3.—Saturate the muriatic solution with carbonate of potassa, if the precipitate is white it may be at once reduced by a little resin and charcoal powder in a crucible, as before mentioned; but if it has a dirty green appearance it probably contains copper, to collect this redissolve the precipitate in muriatic acid, and immerse in the solution a cylinder of tin of known weight, the copper will fall.

4.—The copper separated, washed, and the liquors mixed together, a plate of zinc is to be immersed, this will separate the tin in the metallic state, and which, when dried and fused will give, after deducting for the loss in weight of the cylinder, in process 3, the quantity contained in the ore.

If the ore examined has contained nothing else than tin mineralized by oxygen, a con-

siderable loss of weight in the product will occur, and which is therefore to be set down to that body; there may be as much as 20 per cent, and sometimes even a little more; a second analysis should however be instituted in all such cases, which will determine it.

Reduction.

The reduction of the ores of tin, as practised in Cornwall, is as follows:—

The common tin ore, tin stone, having been brought out of the mine is first broken into small pieces, from whence it is transferred to the stamping mill, where it is reduced to the state of coarse powder; a current of water continually removing this powder as it is formed, separates the lighter impurities, whilst the heavier particles are collected in reservoirs made for the purpose.

After the ore has been freed by washing as much as possible from extraneous matter, it is called black tin, and in this state is sent to the furnace to be roasted with a gentle heat, this drives off nearly the whole of the sulphur or arsenic that may have been combined, at the

same time that a considerable portion of the iron is turned into a light red oxide, which is separated by again washing with water. The residue is now returned into the furnace, mixed with small coal, and after five or six hours the reduced metal is withdrawn by a plug inserted in the lower part for the purpose. The metal thus obtained is again exposed to a low heat, that part which first melts is drawn off, and is denominated grain tin, the heat is now increased, and the residue, after being run into moulds, is called common tin, and usually contains a small portion of copper and arsenic.

Stream tin being nearly a pure oxide of the metal, often containing upwards of 75 per cent. of metal, there is no necessity for any after purification. This variety is therefore simply washed in a running stream, by which any adhering earthy matter is separated, reduced to a coarse powder, mixed with charcoal and submitted to the action of a blast furnace, the reduced metal is afterwards run out and tested by taking up a little in an iron ladle, and again pouring it back in a stream; if it appear of a silver brightness, and an uni-

form consistence it is sufficiently pure, and all that is necessary is to cast it into moulds forming what are commonly called pigs, and receiving the stamp of the duchy, for which it pays four shillings per cwt.

The uses of the metal.

Tin is much used as a covering to several other metals, iron is tinned to prevent its rapid oxidation when exposed to air and moisture, and the same process is applied to copper to avoid the injurious effects to which those who are in the habit of employing cooking utensils made of this metal are always liable. The solutions of tin in the nitric, muriatic, nitro-sulphuric and tartaric acids, are much used in dyeing, as giving a degree of permanency and brilliance to several colours, to be attained by the use of no other mordants with which we are at present acquainted; tin forms the basis of pewter, in the composition of which it is alloyed with lead, when rolled into thin sheets it is called tin foil, and is applied, with the addition of mercury, to cover the surface of glass, thus forming looking glasses,

mirrors, &c. and in combination with sulphur it constitutes what is called mosaic gold.

ZINC.

The ores of zinc are very generally dispersed through the different lead mines of this country; they are also met with in Sweden, Saxony, Bohemia, and North America. The principal varieties are—

Blende	Zinc and sulphur,
Red zinc	Zinc, oxygen, iron and manganese,
Electric Calamine	Zinc, oxygen and silica,
Calamine	Zinc, oxygen, and carbonic acid,
White vitriol	Zinc, oxygen, sulphuric acid and water.

Blende is found of three colours, viz.—black (commonly called black jack by the miners), brown, and yellow, in the crystallized fibrous, massive, phosphorescent and mammillated forms. This variety is usually soft, specific gravity a little above 4.; besides zinc and sulphur, it often contains iron and silica, and occasionally arsenic and alumina.

Red zinc is an oxide of the metal, and its constituents are as before stated: it is easily acted upon by the point of the knife. Specific gravity 6.2

Calamine is the most common of the zinc ores, it is fusible, and of a yellowish brown colour. Specific gravity 4.3 It is found in lime-stone in Derbyshire, accompanied with galena, quartz, &c.

White vitriol is an hydrated sulphate of zinc, and is generally found crystallized and of a white colour; it is a scarce variety, and is formed by the absorption of oxygen from the atmosphere, by the sulphuret.

Before the blow-pipe the ores of zinc generally first evolve sulphur and arsenic, on charcoal the metal is revived and burns with

a brilliant bluish white flame, changing at the same time into a light powder, which is the peroxide of the metal. Alone this oxide is infusible, with glass of borax it forms an opake enamel if the oxide has been added in excess, but if not a transparent glass. By continuing the heat, the metal is volatilized, and condenses on the support as before mentioned.

Tests for

Zinc is readily dissolved by most of the mineral and vegetable acids. Strong nitric acid acts most violently upon it with the extrication of caloric, converting it if sufficient acid has been used to the state of a white peroxide, but if not to the protoxide, which is yellow: with

Ferrocyanate of potassa	White precipitate,
Sulphuretted hydrogen and the hydro-sulphurets	Ditto ditto

Caustic and carbonated alkalies	White precipitate,
Solution of galls	No precipitate.

Assay.

On account of the extreme volatility of this metal when exposed to heat, the assay is better conducted by distillation in a coated green glass retort than by any other mode; having therefore reduced a certain quantity, freed as much as possible from the matrix, to fine powder, it may be roasted with a gentle heat in a muffle, this will separate any arsenic and sulphur after which it may be mixed with lamp black or charcoal powder, placed in a retort, and exposed to a red heat, the metal will rise as with arsenic and condense in the neck, the end of which may be loosely stopped, or dipped into a little water.

Analysis.

The analysis of the ores of zinc is occasionally rather complicated, it may be thus effected:—

Process 1.—Reduce a given weight to fine powder, and as some varieties are hydrates, submit to the temperature of boiling oil or mercury; this will drive off the water; estimate the loss.

2.—Digest the ore without heat, for two or three days, in dilute nitromuriatic acid; if any caloric is generated in the process, it should be kept down by immersing the vessel containing it in cold water; stir the mixture occasionally with a glass rod, and pour off the clear liquor; repeat this process if much remain, and well wash with hot water. The residue after this will be sulphur and silex: separate by burning on the flame of a spirit lamp. Estimate the quantity of sulphur thus lost.

3.—Examine the residue, supposed to be silex, it may have a portion of sulphate of lead intermixed; if this is the case, digest the whole in sulphuric acid, this will take up the lead, which is to be separated from the undissolved silex, and the former may be decomposed with a boiling temperature in a solution of carbonate of potassa, carbonate of lead will

fall, which should be collected, dried, and reduced to the metallic state. To ascertain the quantity of sulphur acidified by the nitric acid, and which was combined with the lead, but now with the potassa, note the difference in weight of the residue, before and after digestion in the sulphuric acid; this will give the quantity of sulphate of lead, from which the equivalent quantities of acid and base may be estimated.'

4.—The solution No. 1 may now be tested for any free sulphuric acid, and acetate of barytes added, until no further precipitation; this is to be collected, dried, its equivalent of sulphur obtained, and added to the former quantities, this method will give the whole of this substance contained in the ore.

5.—Or the residual solution may be tested for lead, and if contained, which will be the case if any sulphate of this metal was found in the residue, it may be thrown down by the sulphate of soda.

6.—Test a drop of the liquor with caustic ammonia, if a blue tinge is perceptible, it contains copper, which is to be thrown down by immersing into the acid solution a clean

plate of iron, of known weight, as before mentioned.

7.—Decompose the solution now holding zinc and iron, by carbonate of soda; the carbonate of zinc and oxide of iron will be thrown down. Digest this precipitate in ammonia, the former will be dissolved, while the latter remains, and which may be reduced to the magnetic state by heating in a crucible, with charcoal.

8.—The ammoniacal solution may now be slightly supersaturated with muriatic acid and carbonate of soda added; the carbonate of zinc will thus be obtained pure, and may be brought to the metallic state with a little charcoal or black flux in a retort, or close crucible heated to redness.

Reduction,

The method of reducing the ores of zinc was for a long time unknown in this country, and it is stated that the process was obtained from the Chinese by a person who went over for the purpose. It is as follows:—

The ore, having been brought out of the mine, is broken into small pieces, and submitted to a gentle heat in a reverberatory furnace, until the carbonic acid, sulphur, and other very volatile substances are expelled; after this it is transferred to large jars made of baked clay, each of which has a pipe passing through the bottom and rising nearly to the top of the vessel in the inside; they are also furnished with covers, which are now luted on air tight. When six or eight of these jars are thus filled, they are placed in a long furnace, the lower end of each pipe passing through the iron floor or grating, and dipping at their extremities into a vessel of water. The fire is now lighted, and the zinc after rising in sublimation, is obliged to descend through the pipe into the water, where it collects in a granular form; the whole process is therefore merely that of distillation.

Zinc thus obtained is a metal of a bluish white colour, sp. gr. 7.2, of easy solubility in acids, giving out with many of them, when diluted, abundance of hydrogen gas, arising from the decomposition of the water in the

diluted acid; the metal here combines with the acid to form a soluble salt, whilst the hydrogen escapes, for the liberation of which zinc is chiefly used in the laboratory; not forgetting, however, the formation of the galvanic battery, one of the most powerful instruments when on an extended scale which the chemist possesses. Zinc furnishes no colours to the painter, but the ore is used very largely to form the alloy called brass. To prepare this metal, calamine (native carbonate of zinc) and copper plates are laid stratum super stratum in a crucible, on the application of heat the zinc rises in sublimation, and alloys itself with the copper now at a bright red heat, and which as soon as the alloy is complete, is sufficiently fusible to fall to the bottom of the crucible. Brass is not made by direct union as in most alloys, the heat required for the fusion of the copper being sufficient to dissipate and burn the zinc before it could have time to unite. A salt of zinc and its oxide are also used in medicine. Although this metal is extremely brittle, it may easily be rolled into thin sheets, if previously heated to about 300 degrees Faren-

heit. When melted and run into hot water, and thus granulated, it is called spelter, and is used for hard soldering,

IRON.

This metal, in some shape or other, is very generally distributed through most parts of the world, and its ores, of which there are several varieties, are in general combinations of iron with more or less oxygen, or with sulphur. The oxygenated varieties are either black or red, the former containing the least, and the latter the most gaseous matter; this last is also sometimes combined with carbonic acid. The best iron for many purposes, comes from Norway and Sweden, but the largest quantity is raised in England and Wales.

Iron is of a grey colour with a metallic lustre, considerably hard, ductile, and malleable.

Varieties.

Native Iron	
Arseniate of iron	Iron, oxygen, arsenic acid.
Iron pyrites	Iron, Sulphur.
Oxydated iron Specular iron	Iron, oxygen, &c.
Red iron ore Brown ditto Black ditto	Iron, oxygen, &c.
Clay iron stone	Iron, oxigen, manganese, &c.
Bog iron ore	Iron, oxygen, manganese, phosphoric acid.
Pitchy iron ore	Iron, oxygen, manganese, sulphuric acid, &c.

Spathose iron ore	Iron oxygen, carbonic acid.
Phosphate of iron	Iron, oxygen, phosphoric acid, &c.
Green vitriol	Iron, oxygen, sulphuric acid, &c.
Chromate of iron	Iron, oxygen, chromic acid.

Native iron is found massive, and sometimes globular, as also in the form of plates; it occurs in veins, interspersed among iron stone and quartz, and has all the properties of malleable iron.

The globular specimens are said to fall from the heavens, whence called meteoric native iron.

The arseniate of iron is found massive, but usually crystallized; it is transparent, and occurs of a brown, green, yellow, and sometimes of a red colour; it often contains a small portion of silex and oxide of iron.

Of iron pyrites there are several varieties, which differ mostly in the form of their crystals: the commonest of these occurs massive,

and crystallized in cubes. It possesses considerable lustre, and is of a bronze yellow colour, softer than quartz, and sometimes contains a small quantity of silver and gold, when it is called argentine, or auriferous pyrites.

Specular Iron ore, or oxydated iron, is of a dark steel grey colour, and is found massive, and crystallized, having a metallic lustre; it is slightly magnetic; occurs in primitive mountains, and consists of black oxide of iron, with a small quantity of phosphate of lime. One variety of this ore which occurs in mica slate, is called micaceous specular ore, from its cleaving into thin plates.

The red and brown iron ores, occur massive, and crystallized in various forms; lustre shining, when newly broken; slightly magnetic. They are brittle, but not very hard, and are sometimes termed kidney iron ores.

Black iron ore is a rare mineral, usually found in Germany; it is of a blackish grey colour, magnetic, and possesses a slight metallic lustre.

Clay iron ore, is of a grey or reddish brown colour; massive, and sometimes of a slaty

texture: it occurs globular, columnar, pulvurulent, &c.

The bog iron ore, is a variety of the red iron ore; it has an earthy fracture, and is generally of a dark brown colour, there are several kinds of it, between which there exists, however, but little difference; it contains a small portion of phosphoric acid.

Pitchy iron ore is massive, and glistening, black, hard and brittle; it is found near Limoges in France, and sometimes contains phosphoric acid.

Spathose iron ore is slightly transparent, and of a yellowish grey or white colour; it occurs in imperfect rhombs in veins, in primitive mountains; it is abundant in Spain, and yields a valuable iron.

Phosphate of iron, or earthy blue iron, is of a dark blue colour, and friable texture; it occurs in Cornwall, in the form of four sided prisms, which are not attracted by the magnet.

Green vitriol, or sulphate of iron, occurs native, in romboidal crystals of an emerald colour; it effloresces slightly in contact with

dry air, and is soluble in water, having a strongly feruginous taste. It is mostly found among iron pyrites, from the decomposition of which it always results.

The ores of iron generally vary in specific gravity from 2. to 6. the blackest and most metallic being usually the heaviest. The pure metal has a specific gravity between 7. and 7.8.

By the action of the exterior flame of the blow-pipe, most of the iron ores are blackened, by bringing them to the inner flame they become magnetic, and often run into a black slag. Upon the charcoal support they are mostly reduced into a species of cast iron, but the heat must be kept up for some time.

The pure oxide of iron treated with glass of borax, fuses into a black enamel, which may also be reduced upon charcoal.

With the oxyhydrogen blow-pipe the metal burns off, producing very beautiful scintillations, and this is particularly the case if steel wire is employed.

Tests for Iron.

Liquid ammonia with proto salts	Black precipitate,
With per. salts	Red ditto,
Ferro-prussiate of potassa	Blue ditto,
Infusion Galls with per. salts	Black ditto,
Sulphuretted hydrogen	Ditto.

Assay.

In assaying the ores of iron, they should first be roasted at a strong red heat, as long as any vapours arise; two parts of the mineral are then to be triturated, with one of fluor spar, one of charcoal, and four of common salt; the mixture put into a covered crucible and exposed in a blast furnace to a strong heat for one hour, after which, if the operation has been well conducted, a button of cast iron will be found in the crucible, and by which the value of the ore may be ascertained. If the ore contain much stony mat-

ter, one part of black flux should also be added to the above mixture.

Analysis.

The analysis of the ores of iron is generally a matter of but little difficulty, the pitchy iron ore for instance, usually consisting of the oxides of iron and manganese, united to sulphuric acid, may be thus treated:—

Analysis of iron cent.

Process 1.—A given weight of the ore having been taken and inserted in a flask, pour upon it such a quantity of diluted muriatic acid as will take up every thing but the siliceous matter which may be contained: filter and well wash the residue with water.

2.—Having added together the solution and washings of the last process, drop in muriate of barytes until no further precipitation takes place; filter, to separate the sulphate of barya thus formed; wash the precipitate with water; dry, and estimate the quantity of sulphuric, acid contained, by the scale of equivalents.

3.—The liquors now containing iron and manganese may be concentrated by evaporation and a small quantity of nitric acid added to peroxidize, and thus render more easily separable the oxide of iron; now pour into the solution caustic ammonia in excess; the iron will fall, and may be brought to the magnetic state by heating in a crucible, with a little wax or linseed oil.

4.—Drive off the excess of ammonia by heat, oxide of manganese will fall; it may be reduced in the same way as the oxide of iron.

Those varieties of iron ore in which a considerable quantity of silica exists, as in the magnetic, specular and hæmatitic native oxides, and which are readily distinguished by the feeble action which the acids have upon them, are to be fluxed with three or four times their weight of potassa, in the same way as the reader will find directed under the head Silicium, after which muriatic acid will readily effect a solution of the whole of the iron, and which may afterwards be obtained in the magnetic state by precipitation with a solution of potassa or ammonia, and exposure to heat as usual.

Reduction of the ores of iron.

The iron ore, after it is brought to the surface, is first broken into small pieces by the powerful aid of the stamping mill, after which it is roasted to drive off the sulphu and other volatile substances that may be contained, transferred to the smelting house, mixed with lime and coke, and reduced to the state of cast iron. When the fusion of the ore appears to be complete, the furnace i tapped and the liquid metal runs out into moulds, after which it is called pig iron. This is again broken up and removed to another furnace, where it undergoes the process of puddling, which is thus performed:—a number of pigs assorted of different degrees of carbonization, so as to produce when melted an uniform mass of grey metal are run down by the assistance of blast bellows, where it remains to allow of the scoria containing the impurities to rise to the surface, after which it is a second time run out into moulds and subsequently broken to pieces. A common reverberatory furnace, heated by coal, is now

charged with a quantity of this half-refined iron, after a short time the metal will appear nearly fused, when the flame is turned off, and a little water sprinkled on the surface; when a workman with an iron bar, shaped like a hoe, and introduced through a side opening in the furnace, begins to stir the half fused mass in every direction, until it is reduced to the size of gravel. The flame is now turned on again, and the mechanical action repeated until the iron ceases to emit a blue flame, and appears still and quiet. The heat is now increased, when a strong internal motion, termed by the workmen fermentation, and accompanied by a loud hissing noise takes place; after which the metal begins to clot, and becomes much less fusible than before, when it is collected together into lumps, and beaten with a heavy-headed tool. Finally, the tools having been withdrawn, the flame is again turned on with its full force, when the iron having been brought to a full welding heat, is removed, shingled, and subsequently heated and passed through grooved rollers. By this means the scoria is separated, and the metal acquires a high degree of tenacity.

For a detailed account of the methods adopted in the working of iron and steel, the reader is referred to Aikin's Chemical Dictionary.

Uses of iron.

Iron is a metal so well known in consequence of its indispensible necessity, as to require but little attempt at the enumeration of its uses. Its alloys with carbon or charcoal, are three in number, viz.:—Steel, cast iron, and plumbago, commonly called black lead. In combination with acids it forms salts much used in dyeing, ink making, calico printing, &c. It is also frequently used in medicine as a tonic. It is the colouring matter of several ochres used in painting, the basis of the fine pigment called prussian blue, and as a metal, it is valuable wherever sharpness of edge, firmness of texture, durability and cheapness are requisites.

MANGANESE.

Although manganese is found very universally distributed, its ores, properly so called, are not numerous. It is found in primitive mountains, and mostly in primitive countries; but from the strong affinity it has for oxygen, it never occurs in the metallic state. The ores of manganese are abundant in Somersetshire, Cornwall, and many other parts of Great Britain; as also in France, and Germany.

Varieties.

Grey oxide of manganese	Manganese oxygen.
Siliciferous oxide or white manganese	Manganese, oxygen, iron, silex, &.
Sulphuret of manganese	Manganese, oxygen, sulphur, and carbonic acid.

Phosphate of manganese	Manganese, oxygen, iron, and phosphoric acid.

Grey oxide of manganese occurs crystallized, but generally massive, and compact. When newly broken, it exhibits a metallic lustre, much resembling that of cast iron. It is sometimes of an earthy texture, and in this state soils the fingers.

Siliciferous oxide of manganese, or white manganese, is found massive, often in veins of gold and tellurium. It generally has a yellowish or reddish tinge, and mostly contains some lime.

Sulphuret of manganese is massive, and of a dark grey colour, much resembling the grey oxide. It is found in the same situations as the last mentioned variety, and also, in Cornwall.

Phosphate of manganese is a rare mineral, of a light brown colour. It is found crystalized, possessing a glistening lustre, in a vein of granite in France, and is sufficiently hard to scratch glass.

The specific gravity of the ores of man-

ganese varies from 2.8 to 5. the white variety being the lightest. The pure metal, which is very difficult to obtain, has a specific gravity of about 7.

By the action of the blow-pipe, the ores of manganese, *per se*, become pulverulent; they are not reduced to the metallic state upon charcoal, although they give out their oxygen. When treated with borax, they fuse into a violet coloured glass. The phosphate of manganese is fusible *per se*, forming a black enamel.

Tests for manganese.

With alkalies,	White precipitate, turning black on exposure to the air.
Ferroprussiate of potassa,	White precipitate.
Infusion of galls,	Ditto, ditto.
Water impregnated with sulphuretted hydrogen,	Ditto, ditto.

Assay.

The assay of the ores of manganese is attended with considerable difficulty, on account of the high degree of temperature necessary to deprive them of the last portions of oxygen, for which this metal has a strong affinity. The best method therefore, in general analysis is to reckon the quantity of reguline metal from the pure per oxide. That manganese can be obtained in the metallic state I am fully aware of, having produced it more than once; but it is a task requiring much time and labour, as I never could effect its reduction without the aid of a large pair of bellows and that long continued; and when at last obtained, it possesses no property sufficiently interesting to compensate for the labour.

As the native oxide of manganese always contains iron, its correct assay can never be effected intirely in the dry way, the manganese being more refractory than the iron itself; it is, therefore, the best method to make a solution of the native black oxide in muriatic acid, this will take up all the oxide

of manganese, together with the oxide of iron; but upon the addition of caustic ammonia in excess, the latter will fall, leaving the former in solution, and which is afterwards obtained by evaporating to dryness, and exposure of the residue to a red heat. The pure oxide thus obtained, may be reduced by mixing it into a paste with oil and a little charcoal, and submitting it in a good crucible to a violent heat for an hour or more; the button thus obtained is magnetic and of an iron grey colour; it very soon tarnishes, and is hard and brittle. When the pure oxide of manganese is mixed with oil, and submitted to the action of the mixed gases, the surface after some time assumes a metallic appearance; but I never could obtain a perfect globule of metal.

Analysis.

The variety called white manganese, and which consists of oxide of manganese, oxide of iron and silex, may be analysed as follows;—

Process 1.—Digest upon 100 grains of the ore with the application of heat, a sufficient quantity of moderately strong muriatic acid, until nothing remains undissolved but a white

powder, which being washed, dried, &c., is the silex of the ore.

2.—Add caustic ammonia to the clear solution as long as any precipitate is given, which will precipitate the iron contained in the ore; separate this by a filter, wash, dry, and reduce to the magnetic state.

3.—Put all the liquors together, evaporate to dryness, and wash the residue with distilled water, the powder now remaining is the oxide of manganese contained in the ore.

Uses of Manganese.

Manganese, although found very abundantly in the state of an oxide, has never been applied to any useful purpose in its reguline form; as obtained in its native state it is used in glass-making, in which it acts as a bleacher, rendering this substance much clearer and more free from those stains to which it is always liable from the different impurities contained in the alkali, as well as the iron contained in the flints. In the laboratory, the native oxide is used for the production of oxygen gas, which it liberates to a certain extent very freely, and for that purpose the ore broken

down to a coarse powder, is much better than that which is finely divided. When mixed with muriatic acid, or with common salt and sulphuric acid, it disengages chlorine, a gas much used, in combination with lime, by the bleachers, for whitening linen and cotton goods. The oxide is also used in French Pharmacy.

POTASSIUM.

Potassium is the base of the oxide potassa, or, in other words, of the alkaline part of pot and pearl ashes, the first being an impure hydrated deutoxide of potassium, and the latter, the same, combined with rather more carbonic acid: but with otherwise fewer impurities. The existence of the base just mentioned was first proved by Sir H. Davy; and the method of obtaining it at a reasonable expence, by the French chemists. The first gentleman effected it by means of galvinism, the latter by what is commonly termed the gun barrel apparatus, which is as follows:—Having

obtained a strong gun barrel, as free from rust and flaws as possible, take out the breeching by unscrewing the end. Having done this, place the middle of it on a forge fire, and slightly bend it, making another slight turn within four inches of the thickest end, and in a contrary direction. To the same end is to be attached a short copper tube, four or five inches long, and which when used is to be luted to it air tight. At the two extremities are to be inserted, also air tight, two corks perforated, to allow of two glass tubes, bent at right angles, being affixed, one of which, when in action, dips into a vessel of mercury, and the other of water; the mercurial one being placed at that end which is the farthest from the fire. Having proceeded so far, the corks at each end may be taken out, and the barrel luted with good fire clay, along that space which is between the two bends, and which is afterwards filled with iron turnings. The lute being dry, the furnace with a good pair of double bellows attached ready, and the iron turnings introduced, the barrel is to be placed in an inclined but horizontal position, the luted part being inserted in the fire,

The potassa is now to be introduced at the long end, farthest from the fire, the corks and tubes made air tight, and the ends dipped into water and mercury, as before stated. Every thing being now ready, the bellows are to be worked gradually but firmly, raising the fire to a full cherry red, or dull white heat; the potassa now fuses, and runs down into that part occupied by the iron turnings, here it is decomposed, the oxygen uniting with the metal at the same time that the hydrogen of the water is given off. The potassium thus formed sublimes into the copper tube, where it is cooled and retained; as also very frequently happens in that part between the copper and the bend of the gun barrel. When no more gas is given off, it is a sign that the process is finished, the fire is therefore allowed to cool, the apparatus taken to pieces, the potassium removed by a knife, and immediately put into naptha, to prevent its oxidating. It occasionally happens that the gun barrel fuses in the middle of the process. Should this accident happen, it is immediately made known by the sudden cessation of the

gas which passes over, the barrel must therefore be got out as quick as possible, and an endeavour made to save that part of the potassium which has been already formed.

The chief difficulty in making potassium, if any can be said to exist, is in affixing the lute which is liable to crack by the heat, and I have often found a small quantity of asbestos mixed with the clay, of much service in preventing it; the quantity of potassium obtained in one operation with this apparatus, is generally from 80 to 100 grains; with a different apparatus, however, the French chemists assert that they have produced several ounces at a time, and that they have obtained it by merely distilling the bitartrate of potassa at a bright red heat in an iron bottle. Here the carbon of the tartaric acid unites with the oxygen of the potassa, and the potassium thus formed is volatilized by the heat employed. The iron of which the bottle is composed probably assisting in the decomposition. Potassium formed by either of these methods, is of a white colour, resembling silver, malleable at common temperatures, but

at 32 degrees hard and brittle: at 50 it may be moulded by the fingers, and fuzes at 137 Farenheit; but requires a heat approaching to redness to make it sublime.

The sp. gr. of potassium is 0.8, reckoning water as unity; when thrown into this fluid a portion of it is instantly decomposed, the oxygen combining with the potassium, to form a solution of potassa, while the hydrogen passes off and takes fire by the intense action thus produced.

Potassa occurs in a combined state in several minerals, of which the following are the principal, and to which Mr. Phillips, in his Mineralogy, has given the term alkaline earthy:—

Mica, Lœusite, Andalusite, Blue Felspar,	Silex, alumina, potash, &c.
Apophyllite	Silex, lime, potash, &c.

Scaly Talc Lepidolite Hauyne Pearlstone Felspar Adularia common compact glassy Labradore	Silex, alumina, lime, potash, &c.
Talc crystallized massive indurated Green Earth	Silex, magnesia, potash, &c.
Soapstone Steatite Potstone Agalmatolite	Silex, alumina, magnesia, potash, &c.
Chlorite crystallized compact Chlorite slate earthy	Silex, alumina, potash, and soda.

Schorl Killinite	magnesia and potassa.
Nitre crystallized capillary investing	Potash, nitric acid.

Tests for.

The solution of potassa changes—

Turmeric paper,	Brown.
Brazil wood,	Purple.
Vegetable blues, except litmus,	Green.

With muriate of platina, Yellow precipitate.

With Tartaric acid in excess, A crystalline precipitate of bitartrate of potassa.

Potassa may be obtained by igniting crystals of tartar, the supertartrate of the salt, in a clean crucible made red hot in the fire; in this process the acid burns off, leaving the oxide combined with a little carbon behind, and this may be separated by solution

in water, and subsequent evaporation in a silver crucible. After it is fused it may be poured out on a clean iron plate, and is now the hydrated oxide of potassium; another method is, to make a caustic lye by adding quick lime to a solution of pearl ashes, evaporating the clear liquor, and susequently digesting the fused mass in alcohol.

The clear alcoholic solution is again evaporated or distilled, and the pure potassa in an hydrated state remains. For this process silver vessels are absolutely necessary.

Analysis.

The presence of either potassa, soda, or lithia, in a mineral, may occasionally be inferred from the loss in weight of the products obtained, compared with what it should be. To ascertain if this is the case, reduce a given weight of the mineral to fine powder, and fuse it with boracic acid, or nitrate of barya; digest the mass so obtained in dilute muriatic acid, and evaporate to dryness; pour water upon the residuum; filter the liquor, to separate the silica and boracic acid deposited

during the evaporation, and decompose the clear solution by subcarbonate of ammonia. Upon heating the mixture, the lime, magnesia, and alumina, that may have been contained in the stone, will be precipitated, and are to be separated by the filter. The clear solution now remaining, is to be evaporated to dryness, and the residue submitted to a red heat, until the muriate of ammonia arising from the union of the solvent, and precipitant before employed is driven off. The new residuum now left, is the potassa, soda, or lithia, combined with muriatic acid. If lithia is contained, digest the mass in alcohol, by which it will be dissolved and thus separated; expel the alcohol from the residue by heat, and turn the muriates into sulphates, which are readily separated by crystallization on account of the insolubility of the sulphate of potassa to that of the soda.

The most useful combinations of potassium are those already mentioned, and commonly denominated potash and pearlash; these come chiefly from Canada, North America, and Russia, and on the large scale are thus prepared:—Having collected together a large

quantity of the branches of trees, of which the wormwood, fumitory, beech, and fir, yield the most, but which are generally taken indiscriminately, they are bound in large stacks, placed over a pit in which the ashes are collected, and from which they are afterwards removed from time to time, to separate the alkali contained in them. The incinerated vegetable matter thus produced is afterwards put into large wooden cisterns furnished with a plug near the bottom. A number of these cisterns being so filled, receive a certain quantity of water, which, at the end of a few hours is suffered to run out by means of the plug below. Another portion of water is again poured on, and, if necessary, a third, until the last runnings are nearly tasteless; the solutions are then evaporated in large iron boilers, and the salt which remains is the pearlash of commerce. The potash is a much more impure article, generally containing a large portion of earthy matter, frequently so much so, that in some samples the inert matter amounts to nineteen-twentieths of the whole.

Potash and pearlash are very extensively used in soap-making, the manufacture of

glass, bleaching and scouring linens, woollen cloths, &c. &c. With the acids it forms salts, some of which are much employed in medicine, either as an antacid, or cathartic. In combination with the nitric acid, it forms nitre, or saltpetre, which enters very largely into the composition of gunpowder; and this salt, when heated, is often used as a substitute for the oxide of manganese in preparing oxygen gas, which it liberates very quickly, and in considerable quantities; the deutoxide of potassium remains behind, combined with a portion of the nitrogen, and thus beautifully shows the composition of the nitric acid. Nitre is never manufactured, from the direct union of its constituent parts, being found ready prepared in immense quantities, a few feet under the surface of the earth, in the East Indies. It is from this salt that the whole of the nitric acid and aquafortis used in commerce is obtained, it being only necessary to add such a proportion of sulphuric acid to it as will form a bisulphate with the base. The residue obtained after the distillation of the acid, is called sal-enixum by the coppersmith, who uses it in the process of pickling; thus producing a clean

bright surface. On account of its alkaline properties, potassa and its carbonate are much used in the laboratory, procuring us in the solid state such substances as were before in solution in acid menstrua; for example, in the preparation of the carbonate (common magnesia), a solution of pearlashes is added to another of Epsom salts, a change in the affinities takes place, sulphate of potassa and carbonate of magnesia being formed in lieu of the sulphate of magnesia and carbonate of potassa originally employed. With chloric acid it forms a compound easily fulminated by trituration with sulphur, and many other substances. The combinations of potassa are also used in an infinity of processes; but which the limits of this little work will not allow of being mentioned.

SODIUM.

Sodium, like potassium, owes its discovery to Sir H. Davy. It is prepared precisely in the same manner from its oxide or soda, as the preceding article is from potassa; and the only difference which exists in its formation is, that it requires a more intense heat, consequently the chances are less in its favour in the process of reduction.

Sodium is of a silver-white colour, and sp. gr. 0.97; it is, therefore, rather heavier than potassium, which, in other respects, it much resembles. When thrown into water it does not produce flame like potassium, but merely effervesces strongly; thus decomposed it passes into solution in the shape of an oxide or pure soda.

Tests for soda.

The solutions of the oxide of sodium are white, and the saline matter left upon evapo-

ration, after absorbing carbonic acid from the atmosphere is efflorescent, while that of potassa and its carbonate is deliquescent.

With solutions of platina	No precipitate.
—— tartaric acid	A very soluble salt.
—— sulphuric acid	An easy soluble salt.

With vegetable colours it indicates nearly the same changes as potassa.

Soda is found in several minerals, of which the following may be mentioned:—

Natrolite, Rubellite	Silex, alumine, lime, soda, &c.
Sodalite, Lythrodes, Analcime, Clinkstone, Pitchstone, Lava	Silex, alumine, lime, soda, &c.
Basalt	Silex, alumine, lime, magnesia, soda, &c.
Pumice	Silex, alumine, potash, soda, &c.

Natron crystallized fibrous massive investing effloresceing	Soda, carbonic acid.
Sulphate of soda	Soda, sulphuric acid.
Borax Tincal	Soda, boracic acid.
Common salt crystallized fibrous massive	Soda, muriatic acid, &c.

Kelp and Barilla.—These two substances, which are largely used by the manufacturers f hard soaps, are prepared from sea weeds in a similar manner to pot ashes, without any separation of the earthy matters with which the alkali is combined, after the process of incineration. Kelp is chiefly the product of the common sea weed which grows upon the rocks between high and low water mark. The makers begin to collect these weeds, chiefly the species *vesiculosus* and *serratus*, about the month of May, and continue until

the end of August or beginning of September. The best, or Alicant Barilla, is made from the ashes of the *salsola soda*, which is very extensively cultivated on the shores of the Mediterranean; and the time for collecting the plants is in August, when the seeds are ripe, and which are shaken out previous to the plant being burnt. In the manufacture either of kelp or barilla the weeds are first dried, and afterwards burned in large furnaces constructed for the purpose; the heat is now continued until the mass enters into a state of imperfect fusion, when the fire is withdrawn. The kelp or barilla thus formed is afterwards removed, and in this state is fit for the market.

It has been already mentioned that one of the chief properties which distinguishes soda from potash is its not readily deliquescing. Soda soaps are therefore hard and soon get dry by keeping; potash soaps, on the contrary, are always soft. Pure soda, or the oxide of sodium, is prepared for experimental purposes by treating the carbonate with quick lime and afterwards digesting the dry caustic alkali in alcohol, as in pure potassa.

The uses of soda, besides the one just mentioned, are very similar to those of potassa; it forms, with the different acids, a numerous class of salts much used in medicine.

LITHIUM.

This substance has only been obtained by the action of the Voltaic battery on its oxide lithia; it is very similar in its appearance to sodium; possessing a brilliant metallic lustre, and is immediately decomposed by water. Lithia may be obtained from three minerals, viz. petalite, triphane, and spodumene: in all these it exists in small quantity.

The method of obtaining lithia from petalite is as follows:—

Having reduced a portion of the stone to fine powder, flux it in a crucible with its own

weight of potassa; boil the residual mass in dilute muriatic acid, and evaporate to dryness; digest the muriates thus formed in alcohol, the muriate of lithia will be taken up, while the others will remain. Throw the whole on a filter; wash the residue with a little more alcohol, add the washings to the clear solution, and evaporate to dryness in a silver alembic: the muriate of lithia now remaining may be decomposed by carbonate of silver, thus forming muriate of silver and carbonate of lithia; and which, after separation of the former, may be rendered caustic in the same manner as the other alkaline carbonates by the addition of quick lime. It has now a sharp acrid taste, similar to potassa, but from which it is readily distinguished by its not deliquescing when exposed to the air, but slowly absorbing carbonic acid.

Tests for Lithia.

The solutions of lithia act upon vegetable colours in a similar manner to the other alkalies, from either of which, however, it may be distinguished by

Phosphoric acid giving a	White precipitate
Carbonic ditto	Ditto, difficultly soluble in water.

Neither lithium nor its oxide have as yet been obtained in sufficient quantities to determine whether it has any properties distinct from its alkaline nature that may be otherwise useful; they are substances but very little known, and the stones from which they may be obtained very scarce.

CALCIUM.

A white metallic-looking substance remaining after lime is negatively electrized in contact with mercury, and the latter driven off by exposure to heat in a close vessel, and to which the name of calcium has been given. Calcium, heated in contact with air, takes fire; oxygen being absorbed, and the lime originally employed remaining in the same state as before.

The oxide of calcium or lime, when combined with carbonic acid, is of very general occurrence, constituting a very large portion of this earth, and commonly called chalk; it often occurs crystallized, as in calcareous spar, arragonite, &c.; fibrous, as in satin spar; and granular in all the marbles obtained from Greece, Italy, or elsewhere. Besides the term marble (one destitute of signification in a chemical point of view), it is called lime-stone, and is then divided into two

classes, the primitive and the secondary; the due consideration of which is of consequence in mineralogy, many metals, for instance, being found in the former, which are of very rare occurrence in the latter, and *vice versa*.

Primitive lime-stone or marble may be readily known from that of a secondary formation, by its not containing those shells and other remains of marine substances which are found in the other. Primitive marbles are generally of one colour throughout, or streaked with veins of one colour, and are usually more compact and granular than the secondary ones; they are very seldom composed of pure carbonate of lime only, generally containing some proportion of silex, which latter varies in quantity from the white Carara, or purest marble, to those which strike fire with steel.

The native carbonates, excepting those just mentioned, which are combined with a large proportion of silex, are readily known by testing with a drop of nitric acid; as, if an effervescence or escape of carbonic acid gas takes place, it is at once indicated, and the comparative facility with which the acid acts.

determines the relative quantity contained. Thus, if a piece of common hard lime-stone is treated with the acid, its action will be impeded by the particles of sand or siliceous matter covering those of the carbonate of lime; if a piece of white marble is on the other hand employed, the effervescence will be immediate and violent.

Note.—A test bottle, or one furnished with a long stopper nearly touching the bottom, containing a small quantity of the acid, and inclosed in a leather or wooden case, is generally employed, and should always be contained in a mineralogical chest.

Besides the native carbonates, the different varieties of which are here enumerated, lime is also found combined with several of the mineral acids, and other earths; thus we have,

Carbonate of lime Calcareous spar Schiefer spar Satin-spar	Lime, carbonic acid.

Stalactitic
Stalagmite
Granular limestone
Primitive marble
Common limestone
Secondary marble
Verd antique.
Lumachelli
Cotham
Swinestone
Bituminous
Argillo-ferrugs.
Calp
Aberthaw
Septaria
Oolite
Peastone
Chalk
Marle
Chalk-marle
Bituminous
Madreporite
Agaric mineral
Aphrite
Tufa

Lime, carbonic acid.

Arragonite crystallized Flos ferri dendritic fibrous	Lime, carbonic acid, strontian.
Bitterspar Miemite Pearl-spar	Lime, magnesia, carbonic acid, &c.
Dolomite Magnesian limestone Conite	Lime, magnesia, carbonic acid, &c.
Apatite Phosphorite	Lime, phosphoric acid.
Fluor crystallized nodular compact earthy Chlorophane	Lime, fluoric acid.
Anhydrite crystallized granular fibrous compact siliciferous	Lime, sulphuric acid.

Gypsum crystallized fibrous plumose compact granular earthy	Lime, sulphuric acid, water.
Nitrate of lime	Lime, nitric acid, water.
Datholite Botryolite	Lime, boracic acid, water.
Pharmacolite	Lime, arsenic acid, water.

Lime is also a constituent part in many other minerals, as the reader will perceive under the head of silicium.

The tests for lime in solution are—

With oxalate of ammonia and oxalic acid	A white insoluble oxalate,
Sulphuric acid and [illegible]phate of soda	Ditto ditto sulphate.

Carbonates of ammonia, potassa and soda	White insoluble carbonates.

Caustic ammonia added to the acid solutions, occasions no precipitate.

Analysis.

In making the analysis of the different minerals containing lime, this latter substance is readily distinguished from that of baryta or strontia by the nitrate neither tinging the flame of a yellow or red colour as in those just mentioned, and also by its nitric and muriatic salts being very deliquescent and difficultly crystallizable; whereas those of baryta and strontia are directly the reverse.

Carbonate of lime may be readily analyzed by introducing into a bottle (previously one-third filled with dilute muriatic or nitric acid, and the gross weight of which has been accurately taken) a definite quantity, say 100 grains, of the dried mineral, the quantity of carbonic acid which is thus expelled will be ascertained by the loss on re-weighing the

having been taken to insert a spiral glass tube or piece of wool into the mouth of the bottle [redacted]t the escape of any aqueous parti-[redacted]h would otherwise rise. The weight [redacted]be or wool is of course to be taken [redacted]ore and after, as with the bottle and

[redacted]Analysis of sulphate of lime.

[redacted]tive sulphates of lime may be analy-[redacted]oiling the mineral previously reduced [redacted]y fine powder with a solution of car-[redacted] of potassa, until a thorough decompo-[redacted] effected; the result will be a change [redacted]ng to their affinities, or sulphate of po-[redacted]l carbonate of lime. The first may be [redacted]d by elutrition with hot water, [redacted]quantity of lime contained in the lat-[redacted]ated by the scale, or reduced to the [redacted]quick lime by a sufficient exposure to [redacted]a covered crucible.

Analysis of fluate of lime.

[redacted]e of lime may be decomposed by heat-

ing the powdered fluor spar in contact with sulphuric acid: fluoric acid and sulphate of lime will be the products. The form[illegible] collected by passing the vapour [illegible] water, and its quantity of real acid [illegible] the quantity of alkali required for i[illegible] tion, and the latter either by reduc[illegible] caustic state, or by reference to th[illegible] equivalents.

Analysis of the native phosphate o[illegible]

Apatite and phosphorite may be exam[illegible] dissolving them in dilute nitric acid, a[illegible] cipitating their base in a combined st[illegible] oxalate of ammonia. The oxalate of l[illegible] formed may be reduced to quick[illegible] heat, as also may the phosphate of [illegible] to that of glacial phosphoric acid.

Before the oxyhydrogen blow-pi[illegible] lime is infusible, but emits a most int[illegible] beautiful light; and when placed b[illegible] prismatic spectrum, or applied to the s[illegible] croscope, the same effect is produced [illegible] the rays of the sun are used. It is t[illegible] membered that in all experiments [illegible]

nstrument, the greatest effect is produced by that part of the flame close to the jet, which is directly the reverse with all other blow-pipes.

Lime is very generally used in the formation of cements and plaisters of various kinds, also as a very powerful flux when combined with silica for the smelting of ores, and in the laboratory for rendering caustic solutions of carbonated alkalies. The native sulphate, or gypsum, when calcined, forms the plaister of Paris so much used for casting figures of various descriptions. Common carbonate of lime or chalk, when purified by grinding and washing with water, forms whitening, and i also the basis of the different testaceous powders used in medicine: when added to a solution of sulphate or nitrate of copper it precipitates the metal, and thereby acquires a blue colour, and is then called verditer.

BARIUM.

The substance which bears this name is to be obtained in a similar manner to that adopted in the preceding article, by negatively electrizing barya in contact with mercury. Sir H. Davy states the metal so obtained to be of a dark grey colour, specific gravity, 2. When heated in contact with oxygen it takes fire and returns to the state of barya, or oxide of barium.

Pure barya may be obtained by submitting the crystallized nitrate to a bright red heat for an hour, in a crucible, or by calcining the pure carbonate; in either case a substance of an ash grey colour is produced of specific gravity about 4. possessing a strong affinity for water, which is absorbed with the extrication of heat similar to that produced on its addition to lime, but in a minor degree. Barya thus obtained is soluble in water, to which it imparts an acrid caustic taste and

poisonous quality; the solution changes vegetable blues to green, and has on that account been called an alkaline earth, it also renders oils miscible with water, but does not form a true soap by boiling with them.

Barya is not found in many minerals, and never in a pure or uncombined state: the varieties are—

Witherite	Barya and carbonic acid,
Heavy spar and hepatite	——— Sulphur and oxygen.

Cawk, bolognian stone, and stangenspath, are also varieties of heavy spar, and harmatome, or cross stone, contains barya in the proportion of 18 or 20 per cent.

Tests for barya.

The solutions of barya give with

Sulphuric acid and the soluble sulphates	A white precipitate of sulphate of barya.
Carbonated alkalies	White precipitates.

The salts of barya are readily distinguished from those of lime by their more difficult solubility, and from those of strontia by the different colour which spirits of wine when burnt upon them assume, the muriate of barya giving a yellow, and that of strontia a red flame.

Analysis.

To make an analysis of either witherite or heavy spar, the former may be effected in a similar way to that of the carbonate of the preceding article, and the heavy spar, as in the native gypsum. Where it is an object to reduce any of the native sulphates in considerable quantities for the purpose of manufacturing their salts with the acids roasting with charcoal, sawdust, or small coal is usually adopted as a cheaper and more expeditious method than that of boiling with carbonate of potassa. In the former instance the carbonaceous matter combines with the oxygen of the sulphuric acid of the sulphate, thus reducing it to the state of a sulphuret, which is again decomposed by a continuance of the heat, the sulphur being dissipated, and the impure

earth or oxide remaining, and which will now readily unite with any of the mineral acids.

Barya and its salts are of very limited application. In the laboratory the latter are frequently in request in the analysis of solutions containing sulphuric acid, either in a free or combined state. The nitric salt is used in the composition of green fire, and its native carbonate, when reduced to a fine powder, as a poison to destroy vermin; also occasionally for adulterating the white oxide of arsenic, which it much resembles as regards its poisonous quality and specific gravity.

STRONTIUM.

Strontium may be obtained in the same manner as the two preceding, viz. calcium and barium; it is found native in combination with the carbonic and sulphuric acids, the

former variety is called strontianite, and the latter celestine, and both of these occur in the massive, crystallized, fibrous, and stellated forms.

The native carbonate of strontia was originally discovered in a lead mine at Strontian, In Argyleshire, from which it derives its name. It is at present a rare mineral, but there is little doubt if this mine was worked, but which has been filled with water for several years, that it would be very plentifully obtained: it has a greenish cast and is of specific gravity about 3.5 Specimens have also been brought from Peru and Saxony.

Celestine, the native sulphate, is the source from which the different salts of strontia are made; it occurs very abundantly in the neighbourhood of Bristol, where it has been used to mend the roads; it is white, often with shade of blue, also occasionally reddish, from the oxide of iron combined; the different varieties vary a little in specific gravity from 3. to 3.5. Arragonite also contains a portion of strontia.

Tests for

Carbonated alkalies	White precipitates,
Sulphuric acid and soluble sulphates	Ditto ditto.

The muriate of strontia tinges the flame of burning alcohol of a fine red.

The solutions of the salts of strontia are decomposed by barya, which latter has a stronger affinity for acids than the former.

Analysis.

The precipitants of strontia and barya, when in solution, being the same, the analysis of the varieties of the former may be conducted in the same manner as for those of the latter; they are afterwards to be distinguished as before mentioned.

Strontia appears to be of little utility; in combination with nitric acid it forms a salt used in the preparation of the red fire of late so abundantly used in almost every theatre, and which is composed of this salt dried and powdered, chlorate of potassa, sulphur, and charcoal.

MAGNESIUM.

The base of magnesia is now generally supposed to be metallic; it has been obtained in the form of a dark grey metallic like film by distillation in *vacuo* of an amalgam of magnesia and mercury, formed by means of electricity, as mentioned under the head of barium, &c.; also by passing the vapour of potassium through magnesia enclosed in a platina tube and heated to whiteness with the subsequent addition, and after evaporation of a portion of mercury. Thus formed, it is stated to be of a dark grey colour, burning with a red light when strongly heated, after which it passes into a white powder, or pure magnesia.

Magnesia, the oxide of magnesium, is generally obtained by strongly calcining its carbonates in loosely-stopped vessels; in this state it is alkaline, as it changes vegetable reds to green. Before the common blow-pipe it is, *per se*, infusible; with the oxyhydrogen pipe it is

agglutinated. Its specific gravity is about 2.3, having but little taste and no smell.

Carbonate of magnesia is generally obtained from the bittern, or liquor remaining after the separation of common salt from sea water. This consists principally of muriate and sulphate of magnesia, and which upon the addition of a carbonated alkali, is decomposed; a carbonate of magnesia being formed, which precipitates, whilst the alkali, either potassa, soda, or ammonia, unites with the acids previously combined with the magnesia, and by which it was before held in solution.

Magnesia is found native in the form of an hydrate, often tinged of a reddish colour, from the presence of iron. It also occurs in combination with silex, alumina, and lime, the carbonic, sulphuric, and boracic acids, as in the following minerals:—

Olivine Chrysolite Bronzite	Silex and magnesia.
Tremolite Amianthoide Diopside	Ditto and lime.

Augite Sahlite Cocolite Pargasite Hornblende crystallized massive hornblende-slate Basaltic Hornblende Actynolyte crystallized asbestiform glassy Hypersthène Schiller spar Smaragdite Anthophyllite Asbestus Amianthus Common asbestus Mountain leather ——— cork ——— wood	Silex, alumine, lime magnesia, &c.
Talc Green earth	Silex, magnesia, and potassa.

Soapstone Chlorite Schorl Killinite	Silex, alumina, magnesia, and potassa.
Basalt	Silex, alumina, lime, magnesia, and soda.
Gabronite	Silex, alumina, and magnesia.
Bitter spar Pearl spar Dolomite Magnesian limestone Conite	Lime, magnesia, and carbonic acid.
Sulphate of magnesia	Magnesia and sulphuric acid.
Boracite	Magnesia and boracic acid.

Besides the above, magnesia is often found constituting a portion of the matrix attached to a great number of the metallic ores, also in many mineral waters combined with the muriatic and sulphuric acids.

Test for.

Magnesia is readily dissolved by most of the acids, either mineral or vegetable; with the sulphuric it forms a bitter solution, which upon evaporation yields crystals, or Epsom salts.

With carbonates of soda and potassa	White precipitate of carbonate of magnesia.
With soda and potassa	White precipitate of pure magnesia.
The bicarbonate	No precipitate, unless heated.
Oxalate of ammonia	No precipitate.

Analysis.

The analysis of the native carbonate of magnesia:—

Process 1.—Dissolve a given weight in dilute sulphuric acid, the carbonic acid will be thus expelled, the weight of which may be ascertained at once if the digestion has been

conducted in a bottle furnished with a curled glass tube, as directed under the head of carbonate of lime.

2.—The liquor in PROCESS 1 having been filtered, drop in a solution of bicarbonate of ammonia; carbonate of lime, should it be present, will be precipitated. Filter the solution, and precipitate with carbonate of potassa: wash this carbonate of magnesia on a filter, calcine with a red heat in a loosely covered crucible for an hour, or until the carbonic acid is expelled; add together the weights of the magnesia, the carbonic acid lost in the first process, together with the carbonate of lime formed in the second, and the weight lost, if the analysis has been carefully conducted, will be the quantity of water originally contained.

For the analysis of those minerals, in which silex and alumina are constituents, see the latter article.

The different earths and stones of the magnesian order, are known by their generally possessing a glittering or shining surface, very seldom an earthy one, with a greenish hue, and soft or soapy touch not soiling

the fingers. They are readily distinguished from the siliceous genus by their infusibility with potassa, and from the argillaceous by not emitting a clayey smell when breathed upon, or contracting and hardening by exposure to heat; they are generally sufficiently soft to be cut with a knife, and do not readily effervesce with acids, but are soluble in boiling sulphuric acid. Their texture is uneven, generally scaly or lamellar. They vary from opake to semi-transparent.

Magnesia and its carbonate are chiefly used as medicinal preparations; the former has been much recommended by Doctor Henry, of Manchester, as an antacid, especially in cases of flatulency; the latter is an universal medicine as a cathartic for children.

SILICIUM.

Silicon and silicium, are terms applied to denote the base of silica, or that substance of which quartz, flints, sand, &c. are composed, and which is readily distinguished by its peculiar insolubility in all the acids, the fluoric excepted. The attempts to obtain the base of silica, supposed to be a metallic oxide, have not been so successful, as with those of potassa and soda, although it would appear that these substances have a much greater affinity for oxygen than silica has.

Silica may be obtained in a pure state by fluxing powdered quartz, with three or four times its weight of caustic, soda, or potassa in a crucible, dissolving out the fused mass with hot water, acidulating with muriatic acid, filtering and evaporating the whole to dryness; the mass thus obtained after well washing with hot water is the silica in the form of a white gritty powder now insoluble in all the acids but the fluoric.

Silex or silica, is universally dispersed over every part of the habitable globe, being not only the principal part of what is often denominated terra firma, but forming the chief constituent in a variety of gems, distinguished by their hardness and beauty, as the garnet, tourmaline, &c. The following is a list of the principal minerals in which silica forms a part, not including those already mentioned under the heads of magnesium, potassium and sodium, many of which belong to silica:—

- Quartz
  - crystallized
  - massive
  - enclosing water and air
  - pearl spar
  - bitumen
  - bitumen and water
  - titanite
  - oxide of iron
  - mica (avanturine)
  - chlorite (prase)
- coloured; milk
  - rose

} Silex, &c.

- violet (amethyst)
- yellow
- brown
- ferruginous (Eisenkeisel)
- irisated

radiated
stalactitic
pseudomorphous
spongiform
fat or fetid
Hyalite
granular
arenaceous (sand)

} Silex, &c.

Cat's-eye
Opal
precious, or noble
fire
common
semi
wood
ferruginous

} Silex, &c.

Hydrophane
Menilite
Flint.
ferruginous

} Silex, alumina, &c.

Chalcedony	Silex, alumina, &c.
pseudomorphous	
onyx	
sard	
sardonyx	
plasma	
heliotrope	
Chrysoprase	
Cacholong	
Carnelian	
Agate	
ribbon	
brecciated	
fortification	
mocha-stone	
moss	
Jasper	
common	
striped	
Egyptian	
porcelain	
agate-jasper	
ruin-jaspar	
Hornstone	
pseudomorphous	
wood-stone	
chert	

Leelite Siliceous sinter opaline Pearl sinter	Silex, alumina, &c.
Tabular spar Lievrite	Silex, lime, &c.
Garnet Almandine Common Pyrenite Grossular Aplome Manganesian Melanite Allochroite Colophonite Pyrope Topazolite Cinnamon-stone Idocrase Pyrgom Prehnite Koupholite Stilbite Albin	Silex, alumina, lime, &c.

Mesotype	Silex, alumina, lime, &c.
crystallized	
fibrous	
pulverulent	
Axinite	
crystallized	
lamelliform	
Wernerite	
Epidote	
crystallized	
granular	
manganesian	
Zoisite	
prismatic	
earthy	
Tourmaline	
crystallized	
white	
green	
yellow	
blue (Indicolite)	
black	
Aphrizite	
Indianite	
Lapis Lazuli	
Dipyre	
Laumonite	

Slates	Silex, alumina, lime, &c.
Clay-slate	
Flinty slate	
Lydian-stone	
Whet-slate	
Alum-slate	
Clays	
Wacké	
Iron-clay	
Indurated-clay	
Slate-clay	
black	
brown	
rotten-stone	
Adhesive-slate	
Polishing-slate	
Porcelain clay	
Lithomarge	
Fuller's-earth	
Tripoli	
Bole	
Lemnian Earth	
Cimolite	
Mountain-meal	
Black chalk	
Pipe clay	
Potter's clay	
Loam	

Harmotome	Silex, alumina, barytes, &c.
Jade common Axe-stone Sausurite Obsidian Marekanite Pettstein Scapolite Chabasie	Silex, alumina, lime, &c.

Besides these varieties, silica occurs as a principal constituent in the matrix of almost every ore.

Analysis.

On account of the extreme insolubility of silica, those minerals in which it exists in considerable quantity, must always be first treated in the dry way (fluxing with potassa or soda), as by this method a compound more or less soluble in water, according to the quantity of alkali employed, is obtained. And as it has been before stated that all mineral substances

are obedient to the action of either alkalies or acids, so by this method obstacles are overcome that might be otherwise insurmountable.

It is to be remembered that in all cases where a solution is required, the substance to be operated upon should be in a divided state, and this is particularly required in the analysis of siliceous compounds; as even with this precaution a failure would often be experienced, were we not enabled by the fixed nature of a caustic alkali to apply a heat four or five times greater than when working in the wet way (digesting in acids). It is also frequently of advantage in the treatment of those minerals which refuse to dissolve in acids, if the finely divided mineral is boiled in a strong aqueous solution of these salts, the particles of the two bodies in this way coming nearer together; but this is usually a preliminary process only, as the water is to be evaporated, and the dried mass afterwards submitted to a low red heat for half an hour or more, according to the quantity and state of the division of the silica contained, as also of the temperature employed.

Indeed it may be generally laid down as a rule, that in proportion as the alkali is in excess, and the mineral finely powdered, so is the time required for the fluxing shortened, and *vice versa*.

In the use of alkaline solvents, the materials of which the vessels so employed are composed, is also to be taken into consideration. If a caustic alkaline ley were heated in capsules crucibles, &c. composed of glass or earthenware, the analysis could not be performed with any degree of accuracy; a portion of the vessels themselves would be dissolved, and thus, in the after process, would give a portion of silica which did not belong to the mineral, besides the certainty of thus spoiling the vessels. All the metals, gold, silver, and iron excepted, are subject to the same defects, and of these the second is by far the best for this description of analysis.

In the process of fluxing therefore, in the small way, three times the quantity of dry caustic alkali, previously ground to fine powder, or its equivalent in solution, should be added to that of the mineral employed, and the two intimately mixed together. The cru-

cible in which the operation is to be performed should be sufficiently large to hold thrice the bulk of the materials so acted upon; otherwise a portion is very subject to fly out, and the analysis rendered inaccurate. The crucible should have a cover, to keep out any pieces of coal which might otherwise get in, and should be made of silver, without any admixture of copper. Platina vessels are not fitted for the process; and those made of silver will not bear more than a low red heat, without danger of fusing, and also require to be inserted within another composed of black lead (carburet of iron), to prevent the coals adhering to the sides, sometimes not removable without violence.

Process I.—A siliceous body, having been duly fluxed, hot water is to be poured into the crucible; or, what is sometimes better, the crucible itself, together with its contents, placed in a clean iron saucepan half filled with water, and made to boil: by this means every particle of matter is readily detached, and nothing lost.

2.—The clear liquor, separated from the undissolved residue is to be quickly

supersaturated, or rendered acidulous, by the addition of muriatic acid, and poured into glass vessels; by this means, although the silica will be at first precipitated, yet, upon a slight excess of the acid, it will again be dissolved. Now evaporate the solution to dryness; pour boiling water upon the dry mass, and throw the whole upon a filter: drop muriatic acid on the residue; again wash with distilled water, and subject the filter and contents to a low red heat. What now remains is pure silica, unless mixed with a little charcoal from the decomposition of the paper which formed the filter, and this may be removed by a stream of air from the lungs, or a pair of hand-bellows.

3.—The residue, untouched by the fluxing in Process 1, and separated from the clear liquor in 2, may now be digested also in muriatic acid; and should any remain undissolved after boiling in this solvent, it is to be again fluxed with three times its weight of alkali, as before, and if necessary, again digested in muriatic acid, or until, by the repeated action of alkali and acid, nothing more remain.

4.—If a second fluxing has been rendered necessary, but which may in general be avoided, another portion of silica is to be obtained by the Process 1, just mentioned; after which the acid solutions are to be all mixed together with the washings of the silica and filters, evaporated, if the bulk is inconvieniently large, and tested to ascertain the constituent parts: there may be two or three metallic oxides, as well as earthy matters.

5.—Whatever metallic oxides may be contained, they are first to be precipitated by the methods already described under their respective heads; after which, if alumina and lime are present, they may be obtained separately, by pouring into the solution liquid ammonia: this will throw down the alumina, and leave the lime, which is afterwards to be precipitated by adding a solution of carbonate of potassa, and boiling the mixture.

Uses of Silica.

Silica is the basis of all the different kinds of glass and china met with in commerce;

the goodness of flint glass consists in perfect transparency, void of colour; and that object is attained by adding to the mixture of flints and pearl-ash a small quantity of the oxide of manganese, called, by the glass-makers, soap, on account of its clearing property. A small quantity of oxide of lead is also generally added in this description of glass.

Green glass, or common bottle glass, is made of much coarser materials than the preceding, its basis being generally sand, with the occasional admixture of lime, and fluxed by barilla, kelp, or wood-ashes. This description of glass is much harder than flint glass, and requires a much greater heat for its fusion: on this account it is often used for the making of retorts and some other chemical apparatus, but has the disadvantage of flying much sooner than the other, on the application of heat.

Glass is often coloured by the admixture of various metallic oxides to form artificial gems, and the whole art in this manufacture consists in first producing a very clear, hard, and perfect glass, and then again fusing it with such a metallic oxide, and in such proportions

as will give the tint required; the following are thus produced:—

Ruby red, by the addition of the purple precipitate of cassius.

Emerald green, by the addition of the oxide of chrome.

Yellow, by the addition of the oxide of antimony.

Blue, by the addition of the oxide of cobalt.

Black, by the addition of the oxide of manganese and cobalt.

If crown or plate glass is used for the basis of artificial gems, a small portion of rock crystal may in general be made to combine by an increased temperature being applied to that originally employed in the manufacture of the glass; and this will tend in a considerable degree to harden, and thereby more nearly approximate the composition to that of a true crystal.

Porcelain differs from glass in its being semi-transparent only, its having a much firmer texture, and capable of sustaining a greater degree of heat before it fuses. It is made in this country, chiefly in Staffordshire, and is composed of a fine clay in which

alumina abounds, and a siliceous stone, called chertz, or otherwise ground flints, made by exposing common flints to a red heat and suddenly cooling them by immersion in cold water, are substituted. By this process the flints are rendered friable, and are then fit for the mill, where they are reduced to an impalpable powder. The dried clay is also made as fine as possible, afterwards sifted, and the two mixed together to the consistence of a stiff paste with water, which is then fit for the workman's lathe. The ware is then baked in a kiln, and is now called biscuit. It is afterwards glazed by dipping it into a mixture of clay, litharge, and ground flints, made up to the consistence of cream with water, subsequently dried, and again exposed to such a temperature as is just sufficient to vitrify the surface: the porcelain is now perfect, if a plain ware only is required. If on the contrary, it is painted with enamel colours, composed of the different metallic oxides, mixed up with a flux, and again baked. In the painting of porcelain some little nicety is required; first, the metallic oxides must be mixed up with the flux

in such proportions as will ensure the vitrification of the whole at one and the same time, otherwise the more fusible would run over the others, and the effect be thus spoiled: and, secondly, those colours only can be used that are neither decomposed by exposure to a very high temperature, nor the lead basis on which they are either applied, or with which they are mixed. The most technical part of the process, however, in the art of porcelain painting, appears to be the exact time at which the fire should be damped; which I am informed by Mr. Anderson, of St. John's street, a celebrated practical enameller, is so critical, that the delay of a few moments over the exact point, is sufficient to spoil a whole kiln of ware; whereas, on the other hand, if a sufficient heat has not been given, the colours will be void of brilliancy, and will bear a dull, rough, uneven aspect, which arises from the flux with which they have been previously united not being fused:—the colours are laid on with turps and oil of spike (lavender), as in oil painting.

ALUMINUM.

This name has been applied to denote the base of alumina, supposed to be metallic, but of which, as it has not been obtained in a pure state, little can be said. From Sir H. Davy's researches it appears, that when iron is negatively electrified in contact with alumina, a compound is formed whiter than pure iron, and which effervesces when thrown into water, at the same time becoming covered with a white powder. When this is dissolved in muriatic acid, and again precipitated by an alkali, alumina and oxide of iron are obtained. Enclosed in a tube and acted upon by the vapour of potassium at a high temperature, the potassium is converted into potass; grey particles, possessing a metallic lustre, are found dispersed through the remaining undecomposed alumina.

Alumina has always been considered, prior to Sir H. Davy's experiments on it, as one of

the primitive earths; it is found in considerable quantities in all the clays, loams, boles, &c. with which we are acquainted, and on the presence of this earth depends their peculiar tenacity and plasticity.

The soil in which alumina abounds is distinguished by the term argillaceous—the name argil being formerly used to denote the pure earth; but as it was afterwards obtained in a state of purity more readily from the decomposition of alum, the bisulphate of alumina, and potassa, the more appropriate term of alumina has been given.

Pure alumina may be obtained by dissolving alum in 20 parts of distilled water, adding to it a small quantity of the solution of carbonate of soda, which will precipitate any iron that may be contained, decanting off the clear liquor, and adding to it liquid ammonia; a white bulky precipitate will now fall, which is the alumina; it is to be thrown upon a linen filter, well washed with repeated affusions of distilled water, collected, and dried: the liquor which passes through the filter is now a compound of the sulphuric acid pre-

viously existing in the alum and the ammoniacal precipitant.

Alumina is also found in nearly a pure state in several minerals, especially the ruby and sapphire, which are composed wholly of this earth, united with a very small portion of colouring matter; it is also a constituent in the following minerals, besides those already enumerated under the different heads of silicium, magnesium, potassium and sodium.

Wavellite Diaspore Corundum Perfect Corundum Common corundum Emery	Alumina water, &c.
Fibrolite Pinite Cyanite Rhætizite Staurolite Automalite Topaz Pyrophysalite	Alumina, silex, &c.

Pycnite, Chrysoberyl, Sommite, Meionite	Alumina, silex, lime, &c.
Pleonaste	Alumina, silex, magnesia, &c.
Iolite, Lazulite	Alumina, silex, lime, magnesia.
Serpentine, Noble, Common	Alumina, silex, lime, &c.
Subsulphate of alumina	Alumina, sulphuric Acid, &c.
Alum, Crystallized, Efflorescing, Stalactitic	Sulphuric acid and potassa.
Cryolite	Alumine, fluoric acid, soda, water.

Tests for.

Alumina, when prepared according to the process just given, is a white, pulverulent substance, strongly adhering to the tongue, in-

sipid, inodorous, and insoluble in water, with which it readily unites, and part of which is retained with great tenacity upon attempting to obtain it in a perfectly dry state; it is infusible except by the oxhydrogen blow-pipe, which agglutinates its particles: in the furnace it merely suffers a condensation in volume; when in the state of powder its specific gravity is 2.

Most of the salts of alumina have a sweet taste, and are very soluble in water, with

Ammonia	White precipitate,
Phosphate of Ammonia	Ditto ditto,
Hydriodate of potassa	Ditto, ditto, passing to yellow.

Bi-sulphate of potassa, added to solutions of alumina, produce octohydral crystals of alum.

Analysis.

Process 1.—The spinel, which is composed of alumina, silex, magnesia, oxide of iron and lime, was thus analyzed by Klaproth—

One hundred grains of the spinel from Cey-

lon, in picked crystals, were reduced to an impalpable powder in a flint mortar. On reweighing, after levigation, an increase of nine grains was obtained, arising from the abraded surface of the vessel employed.

2.—The powder was now digested in muriatic acid, which took up nearly the whole of the oxyde of iron, together with the lime, but did not otherwise affect the mineral; the mixture was therefore diluted with water, and the whole thrown upon a filter: after washing the powder, the clear liquor was saturated with ammonia, oxide of iron fell down, which, upon being collected and dried, weighed 1. 25 grains.

3. The solution separated from the oxide of iron, was concentrated by evaporation, and oxalate of ammonia added; a precipitate was thus obtained, which, when collected, placed on charcoal, and exposed to the action of the blow-pipe, gave .75 of a grain of lime.

4.—The stone having lost very little by digestion in the acid, was next boiled in a solution of caustic potassa, containing five times its weight of dry salt, afterwards evaporated to dryness, and exposed for an hour to a low

red heat in a silver crucible. On dissolving out the contents with boiling distilled water, 54 grains were left unacted upon; they were, therefore, returned into the crucible, with a ten-fold proportion of the alkaline lixivium, and afterwards ignited; on again acting upon the mass with boiling water, 43 grains were left, and therefore insoluble in an alkali.

5.—The clear alkaline solutions previously mixed together, were supersaturated with sulphuric acid, which on the addition of carbonate of potassa, and subsequently boiling, threw down a bulky precipitate: this was again dissolved by excess of acid, and evaporated, when a white powder fell down, which, after collecting and drying, weighed 95 grains.

6.—The precipitate of Process 5, was again digested in an alkaline lixivium, and afterwards reduced to dryness: when again liquified with water, there remained only a slight residue, which, after washing, nearly all dissolved in sulphuric acid.

7.—The portion taken up by this last alkaline solution, was precipitated by the addition of sulphuric acid, but re-dissolved in excess of

acid, and was afterwards precipitated by boiling with carbonated alkali.

8.—The whole of the solutions obtained at process 5, 6, and 7, was evaporated to a small compass; the gelatinous appearance of it, when cold, showed that a separation of silex had taken place; it was then greatly diluted with water, and the silex collected by filtration.

9.—This sulphuric solution was set to crystalize, by dropping into it a solution of acetate of potassa, and evaporating it slowly: the crystals at first were pure and regular ones of sulphate of alumina, but as the solution assumed a green colour towards the end, I combined it with Prussian alkali; a trifling precipitate was the consequence, of which the oxide of iron could not be estimated at more than one-fourth of a grain. The solution, being now free from iron, was decomposed in a boiling heat by carbonate of potassa, and the precipitate, again dissolved in sulphuric acid, was brought to a final crystallization, after which the alum thus obtained was added to the foregoing.

10.—I shall now proceed to the analysis of the 43 grains that were left undissolved by the caustic by Process 4. These were readily dissolved by dilute sulphuric acid, leaving some siliceous earth; the solution separated from the last was then combined with a small portion of acetate of potassa, and exposed to spontaneous crystallization in the open air. At first a few crystals of sulphate of alumina were deposited, but afterwards sulphate of magnesia.

11.—To separate the sulphate of magnesia thus obtained from the sulphate of alumina with which it was combined, it was strongly ignited in a porcelain vessel for half an hour, and the saline mass afterwards softened in water and filtered; the alumina separated by this means was then dissolved in sulphuric acid and crystallized.

12.—The pure solution of sulphate of magnesia was precipitated in a boiling heat by means of potassa. The carbonate of magnesia thus obtained, weighed, when dry, 20dwts. 5 grains, but after strong ignition, only 8dwts. 25 grains.

13.—All the washings (of which that at Pro-

cess 5, on precipitating the sulphuric solution by carbonate of potassa, retained the yellow colour of the first solution, were altogether evaporated to a dry mass; when they were re-dissolved in water, there still separated a little earth, which, along with the precipitate remaining at Process 6, was ignited with caustic potassa, and then, by sulphuric acid, resolved into aluminous and siliceous earths.

14.—The whole quantity of sulphate of alumina obtained at Processes 9, 10, 11, and 13, amounted to 665 grains. It was now dissolved in water, and at the heat of ebullition, decomposed by carbonate of potassa. The aluminous earth thus obtained, when edulcorated with water, and dried, weighed 221 grains; but after being purified by digestion with distilled vinegar, and saturation with ammonia, and being again edulcorated, and at last subjected to an intense red heat, it weighed only 74.5 grains.

15.—I then ignited, for half an hour, all the siliceous earth obtained from Process 8. 10, and 13: it then weighed 24.5 grains. Hence subtracting 9 grains, which had been abraded

from the mortar at Process 1, there remained 15.5 grains belonging to the spinel.

According to the analysis, the constituents of the spinel are :—

Alumine	14	- -	74.50
Silex . .	15	- -	15.50
Magnesia	12	- -	8.25
Oxide of iron . .	2 . .	1.25 -	1.50
	10 . .	.25 -	75
Lime . . .	3		
			100.50

The earths in which alumina abounds, are generally soft to the touch, emiting an earthy smell when breathed upon. They do not effervesce, but are soluble in acid menstrun, generally sufficiently soft to be impressed with the nail, but after exposure to a strong heat become exceedingly hard. The softest varieties readily absorb water, and thus form a tenacious ductile mass.

Uses of Alumina.

Alumina, as before stated, enters largely into the composition of all the different descriptions of porcelain and earthenware; in nature, it is an important feature in primitive rocks; feltspar containing about a fifth, and mica a third, of its weight: but its most beautiful varieties are those distinguished by the term gems—the topaz, ruby, sapphire, &c. being composed of nearly pure alumina. The alum rock is also a very interesting natural product, being the source from whence the immense quantities of alum used in our printing and dyeing grounds, is obtained, where it is employed for the strong affinity it it possesses to almost every description of vegetable colouring matter. In the argillaceous districts, especially those of South America, larger quantities of the more valuable metals are found than in any other; and this is peculiarly fortunate: as although argillaceous earth, when submitted to the action of fire, does not appear to undergo much alteration; yet, when a due proportion of lime is intermixed, the two combine, and readily

enter into a state of fusion, allowing the metal, at the same time, by its great specific gravity, to fall to the bottom.

ZIRCONIUM.

This name has been applied to denote the base of Zirconia, or Zircon, first obtained by Klaproth from the jargon of Ceylon, and since from the jacinth, from either of which it may be obtained in a pure state, as in the following analysis. Zirconia is a white powder, destitute both of taste and smell, with a harsh touch between the fingers; it is insoluble in water, and, unless recently precipitated, is not acted upon either by acids or the solutions of the fixed alkalies. It is infusible; but when the vapour of potassium is passed over it, a similar effect is produced, as already described under the article Alumina.

By the action of the blow-pipe zirconia emits a yellow phosphorescent light: when agglutinated by exposure to an intense heat, it becomes sufficiently hard to strike fire with a steel. Its sp. gr. is 4.3.

The jargon, or zircon, occurs in the beds of rivers in Ceylon, associated with magnetic sand, ruby, tourmaline, &c. also in the sands of a little river in Auvergne, in Saxony, and Norway. Zircon occurs crystallized in many forms, generally not larger than one or two grains in weight; they are smooth and greasy to the touch, and of a smoke-grey colour, which however varies, being also found brown, yellow, and bluish red; the smoke-grey and light yellow are occasionally passed off for diamonds. Jargons are readily distinguished by their great specific gravity, which exceeds that of other gems, being as high as 4.3 to 4.6

Analysis.

1. A given weight of the zircons having been reduced to very fine powder in an agate mortar, they are to be mixed with three times their weight of caustic potassa,

and exposed to a red heat for an hour, at the end of which the mass is to be detached by boiling in distilled water, as usual.

2.—Digest the residue in muriatic acid (should any remain undissolved it is to be again fluxed as before): evaporate the acid solution to dryness, and digest in boiling distilled water, acidulated with muriatic acid; what remains is silica.

3.—The solution now holding the muriates of zirconia and iron, is to be decomposed by ammonia, the precipitate washed to separate the muriate of ammonia, and afterwards boiled in water strongly acidulated with oxalic acid; by this means the iron will be taken up, and the oxalite of zirconia remain; the former may be again obtained bysupersaturation with ammonia, and the latter deprived of its acid by heating in a crucible.

Neither zirconia nor its salts have been applied to any use.

GLUCINUM.

Glucina, supposed to be the oxide of a metal, and to which, therefore, the term Glucinum has been given, is a light, tasteless, white, and soft powder, discovered by Vauquelin, in the aqua marina and the beryl; from the later, it may be obtained in the following manner:—

Analysis of the Beryl.

Process 1.—A given weight of the beryl, in fine powder, is to be fluxed, as usual, with three times its weight of potassa, and every thing soluble removed by subsequent boiling in distilled water to which has been added muriatic acid in excess; evaporate to dryness; digest the dried mass in hot distilled water, and throw the whole upon a filter; what remains, after elutriation, is the silica contained in the stone.

2.—The glucina and alumina, now in combination with the muriatic acid, are to be thrown down by carbonate of potassa: collect the precipitate on a filter; wash with distilled water, and redissolve in sulphuric acid.

3.—To the super sulphate of glucina and alumina, add a small quantity of sulphate of potassa, taking care not to leave any great excess of sulphuric acid in solution: but, if present, it must be removed by the addition of a due quantity of carbonate of potassa; evaporate the solution rather low, and set aside in a covered vessel; crystals of alum will fall, and, by subsequent evaporation, a second portion will be obtained.

4.—When the whole of the sulphate of alumina and potassa have been thus obtained, add carbonate of ammonia in sufficient quantity to dissolve the whole of the glucina, what remains is the alumina.

5.—Filter the ammoniacal liquor in the last process; evaporate to dryness, and ignite in a covered crucible; what now remains is pure glucina.

6.—The quantity of alumina in the crystallized alum is to be ascertained either by

referring to the scale, or by decomposing their solution in water by ammonia, as directed in the preparation of pure alumina; when obtained, its weight is to be added to that portion collected in Process 4.

Glucina has not been applied to any useful purpose.

YTTRIUM.

Yttria was first discovered by Professor Gadolin in a mineral from Ytterby in Sweden, and named, in honour of its discoverer, Gadolinite. This mineral is of a black or velvet black colour; it generally occurs either disseminated or massive, seldom crystalline; with a vitreous lustre and conchoidal fracture; hardness, between felspar and quartz; brittle; specific gravity, 4.2. Its constituents are yttria, silica, the oxides of iron, and cerium and volatile matter. Before the blow-pipe it runs into a slag, which is generally magnetic

As obtained in the following analysis, yttria is a white powder, of specific gravity 4.82; possessing neither taste nor smell; infusible *per se*, but readily so on the addition of a little borax, with which it forms either a transparent or opake glass according to the quantity added. Yttria is soluble in many of the acids, but not in fixed alkalies; carbonate of ammonia, in great excess, however, dissolves it. With the exception of the sulphate of yttria, which is soluble, its salts are very similar to those with base of lime; yttria is supposed to be a metallic oxyde, and the base has therefore been called yttrium.

The soluble salts of yttrium are decomposed by the carbonate and phosphate of soda, oxalate of ammonia and the ferro cyanate, and tartrate of potassa.

Analysis.

1.—A given quantity of the gadolinite in fine powder is to be mixed with thrice its weight of caustic potassa, the mass thus obtained is to be digested in distilled water, and the solution evaporated to throw down

portion of oxyde of manganese generally contained.

2.—The remaining solution, together with the undissolved residue are to be mixed with nitric acid in excess, and evaporated to dryness. On resolution in water, the silex and oxyde of iron will remain: they may be separated by digestion in muriatic acid, which will take up the latter, and leave the former. Ammonia in excess will precipitate the oxyde of iron.

3.—If any lime has been contained in the specimen thus subjected to analysis, a few drops of a carbonated alkali will now separate it, after which, the careful addition of hydro-sulphuret of ammonia will separate the remainder of the oxyde of manganese.

4.—Precipitate the yttria by adding to the remaining fluid caustic ammonia, and the analysis is finished.

THORINUM

Is the last of the substances to be enumerated under the head of metalloyds. It is supposed to be the metallic basis of thorina, an earthy-like matter discovered a short time since by M. Berzelius in the fluate and deutofluate of cerium and yttria.

Thorina may be distinguished from alumina by its insolubility in solution of potassa; from zirconia, by its combination with sulphuric acid, being crystallizable, and by its solubility not being destroyed by the action of heat. Oxalate of ammonia throws down a white precipitate from the solutions of thorina, but they are not affected by sulphate of potassa, which distinguishes them from those of lime.

When pure, thorina is a white powder, having, like lime, a very strong affinity for carbonic acid, which it readily imbibes when exposed to the atmosphere; after which it dissolves with effervescence in acids. With the sulphuric it

forms a crystallizable transparent salt, which is not again altered by exposure to the air. Thorina has not been applied to any useful purpose.

COMBUSTIBLE MINERALS,

Or those with base of Carbon and Sulphur.

CARBON.

This peculiar and supposed simple body, exists in a combined state very generally throughout the universe; but in only one instance yet discovered does it occur in a state of perfect purity, viz the diamond; next to which is a substance to which the term mineral carbon has been applied. As a constituent part it occurs in the following mineral substances.

Plumbago,	Carbon and iron,
Anthracite,	Ditto and earthy matter,
Blind coal,	Carbon and iron,
Stone ditto,	Ditto.

Welch culm,	———
Kilkenny coal,	———
Mineral oil, Naptha, Petreolum,	Carbon, hydrogen, &c.
Bitumen, earthy, elastic, compact, Black coal, Cannel coal, Jet, Brown and other coal.	Carbon, hydrogen, and earthy matter.
Amber,	Carbon and succinic acid.

The first variety of carbon, or the diamond, may be distinguished from most other gems by its greater specific gravity, which is generally 3.5 In its native or rough state, it is usually found coated with a thin crust which produces a slight opacity; and would lead to the idea of its being semi-transparent only, but when this is removed it is nearly equal in that respect to rock crystal. Diamonds are found of various colours, black, blue, red, light yellow, &c.

but the colourless variety which is also of the most frëquent occurence, is the most esteemed; next to which are those containing the greatest depth of colour, as the black, blue, &c. The primitive form of the diamond is a regular octohedron; but it is often found in that of the dodecahedron and the quadrangular prism, with dihedral summits. Diamonds are met with in the Ghauts from Bengal to Cape Comorin; but are principally obtained in the tract between Golconda and Mazulipatam. They are also occasionally brought from Borneo and the district of Serro Dofrio in Brazil, where they are imbedded in a ferruginous sand.

To ascertain whether any specimen is a true diamond or not, a fine file may be used; if the surface of the stone is in the least abraded, or scratched by its action, it is not a diamond. The difference will also appear upon close examination without this instrument: the rays of light easily pass through any other jems, but in the diamond they are refracted to the surface, which occasions that superior brilliancy to what is possessed by any other stones. If the specimen under examination

be very minute, it may be placed between two half crowns, or other flat metallic surfaces, and pressed with the thumb and finger: if a diamond, it will not be injured, but if otherwise, it will break and fall to powder.

On account of the extreme hardness of the diamond, the art of cutting and polishing it was for a long time unknown in this country, when a foreigner of the name of Louis de Berquin, in 1456, is said to have constructed a polishing wheel for the purpose, which was fed with diamond powder instead of corundum which the Chinese employ. Berquin was led to this experiment by observing the action produced by rubbing two rough diamonds together. Diamond powder is now used not only for this stone, but for cutting and polishing many others, particularly where a delicate effect is wanted, as in seal-engraving.

Diamonds are seldom found larger than a hazel nut, and from that down to a very minute size; one half their bulk is also afterwards lost in the cutting and polishing. The largest diamonds are in the possession of the different crowned heads: that belonging to the Emperor of Russia being supposed to be the largest in existence. The value of cut diamonds is

as the square of their weights: thus, if the value of one weighing 1 carat or 4 grains, is worth £8 that of 2 carats is worth £32, of 3 carats £72, consequently according to this rule a cut diamond of 100 carats would be worth £80,000. But after a certain size of about 20 carats, the value does not increase in this ratio, probably from the difficulty of finding purchasers for them.

As the diamond is supposed to be pure carbon, and as such is at present classed among the simple bodies; no analysis can be given: but the following experiments will tend to show its true nature.

EXPERIMENT 1.—If a small diamond is placed in a clean wrought iron tube, and this again after being stopped air tight either by welding together the open end, or what is better, with a stopper made to fit accurately by grinding, is placed in a furnace and urged to a good red heat; that part of the iron on which the diamond rested will have been changed into steel, or carburet of iron, whilst the diamond itself will have disappeared.

2.—Place a diamond, inserted in a small platina capsule, under the receiver of an air pump, and exhaust as much as possible the atmo-

spheric air from beneath: refill the vacuum thus produced with pure oxygen gas and heat the diamond, either by a stream of ignited hydrogen, or by the focus of a burning lens. The diamond will now burn until either itself or the oxygen is consumed, and, on examination of the air within the bell, it will be found to have been changed into carbonic acid gas, from the union of carbon with oxygen. By the above experiments it will therefore appear that the diamond is nothing more than pure carbon, and many attempts have been made at various times to produce the gem artificially, as by fusion of charcoal out of contact with air, but they have from the infusibility of this substance all failed. Another method, and one that would appear in some degree feasible, has been tried, viz. the combustion by the electric spark of a mixture of carbonic acid gas and hydrogen: the oxygen of the former certainly has been made, in this manner, to unite with the hydrogen, and, no doubt, carbon in a pure state has been precipitated. But I am not aware that diamonds have been procured by the process, although I have frequently seen the apparatus made for this pur-

pose, and in one instance it was asserted tha this precious substance had been formed; but the product required the aid of a powerful magnifier to render it visible. A Professor of Chemistry in the United States a short time ago stated that he had succeeded in the formation of diamonds, and that he had produced them of several colours, the colourless variety also; but the only account which I believe he gave to the world was, that he obtained them by the action of the oxyhydrogen blowpipe, or some similar means, on plumbago; but as this substance is a compound of iron and carbon, the former must of course have been volatilized, and as we know that the diamond itself is easily destroyed by heat, it does not appear perfectly intelligible as yet, how he conducted his operations. That a substance may be formed by intense chemical action, sufficiently hard to supersede the use of diamonds for many purposes, is very probable, and that its discoverer may turn it not a little to his advantage also appears as plain; but that the diamond will ever be formed artificially is another thing, not perhaps so likely; although, when the rapid stride which che-

mistry has made within these few years is considered, no one is justified in the assertion of any thing being an impossibility.

Coal, the different varieties of bitumen, and the mineral oils, are also compounds of carbon. To ascertain the quantity of pure carbon in coal, a given portion may be burnt in oxygen gas as with the preceding variety, the quantity of carbonic acid ascertained, and its equivalent of carbon estimated on, or by Kirwan's process, also, it may be thrown, by small portions at a time, into a crucible, containing fused nitre; in this manner he found that 10 grains of Kilkenny coal would decompose 96 of nitrate of potassa, and this is very nearly the quantity of charcoal that is required to produce the same effect; 65 grains of cannell coal, on the other hand, which is not so pure a variety of carbon, were required to decompose the troy ounce, or 480 grains of nitre; but if charcoal had been used, 50 grains would have sufficed. In this instance, therefore, 15 grains of foreign matter must have been contained. To get at the quantity of the earthy and metallic particles contained, expose a given weight of the coal

in a platina dish to a low red heat, in contact with a gentle current of air, the carbon will burn off, leaving the earthy residue behind. If a deficiency in weight still be found, it must be owing to the presence of sulphur, petroleum, or moisture; to ascertain which it must be submitted to destructive distillation, which will give the quantity of volatile matter previously combined.

One of the most useful artificial combinations of carbonic acid, or carbon acidified by oxygen, with which we are familiarly acquainted, is the soda water of commerce, which is made by merely forcing in as large a quantity of this gas as possible into a very dilute solution of carbonate of soda. The assay of a bottle as prepared by Mr. Johnston, and whom I believe to be the best manufacturer of this article, gave a pupil of mine, who assayed it, 98 cubic inches of free carbonic acid. Now as the bottle contained but 9 fluid ounces, the water must have been combined with nearly five times its volume of fixed air.

The use to which carbon, under the twofold shape of coal and charcoal (a natural

and artificial product) is applied, are numerous and important. Besides affording that light and heat which constitute one-half our enjoyments, and without which the remainder would be of little value, it is the means employed for the smelting and reduction, to the metallic state, of all the ores which are found in the bowels of the earth. Alloyed with iron, in different proportions, it forms the compounds known under the names of steel and cast iron; in the form of lamp-black it is used as a pigment, and of bone-black as a very powerful bleacher of vegetable colouring matter. Fresh burnt charcoal, when reduced to a fine powder, is also found very efficacious in the preservation of meat when required to be kept fresh for a considerable length of time; also, in distillation, for correcting any empyreumatic flavour that liquids may accidentally have obtained, and for many purposes which cannot here be enumerated.

SULPHUR.

This mineral substance, also supposed to be a simple or elementary body, is of very general occurrence, both in a free and combined state, throughout nature; in the former it may be divided into two species, native sulphur, and volcanic sulphur, both of which are found in the crystallized, massive, and investing forms. When exposed to a heat below that required for boiling water, it fuses, after which it evaporates, and if in close vessels sublimes unaltered; but if exposed to the atmosphere it imbibes a portion of oxygen, burns with a black light, and passes off under the form of sulphurous acid. When kept for some time in a melted state, or about 300° Ft. it becomes thick and viscid, when cooled by pouring it into water, it is of a red colour, and consistence of wax; and in this state is used by seal-engravers for taking impressions of medals, seals, &c.

Sulphur does not appear at all soluble in

water; but with oil, particularly when heated, it combines in large proportions, and the compound, when cold, varies from a treacle to a buttery consistence, according to the quantity contained; alcohol and ether also take up small portions of sulphur. When fused with caustic alkalies, or boiled with water in contact with lime, sulphurets and an hydrosulphuret are formed, but from which the sulphur may be again obtained on the addition of any acid.

Assay.

On account of the extreme volatility of sulphur the quantity contained in any specimen, either of native or volcanic sulphur, or metallic ore mineralized by this substance, is easily estimated; no other apparatus than the common alembic retort and receiver, or one flask inverted over the neck of another being required. Upon the application of heat to the bottom of the lower vessel, the sulphur rises in sublimation into the upper one where it is cooled and retained; any earthy

or other matter that may have been combined being left at the bottom.

Sulphur is generally obtained in the large way, both from the native sulphur and from the roasting of the various metallic ores with which it is combined, and which are usually denominated native sulphurets, as the pyrites or sulphuret of iron, blende, or sulphuret of zinc, &c. &c.

The principal uses to which sulphur is applied are in the manufacture of gunpowder; and the formation of sulphuric acid, commonly called oil of vitriol, from its having been obtained formerly by the process of distilling vitriol or sulphate of iron in an iron retort, but which is in this country now disused on account of the extra expence that would be incurred when compared with the method at present adopted. Sulphuric acid, as prepared in Great Britain, is obtained by the combustion of sulphur; to effect which three conditions are requisite, viz. oxygen, water, and a close chamber lined with lead, and furnished with side openings to admit air at certain intervals. Thus provided, a quantity of water is first poured on the floor

of the chamber until it rises to several inches in depth, when a portion of sulphur, varying in quantity according to the size of the chamber, and mixed with from 1-8th to 1-10th its weight of nitre is introduced, and set fire to either by pieces of ignited wood, or what is better, by an iron plate, gently heated by means of a furnace placed below, and rising a few inches above the surface of the water in the chamber. The side openings being now made fast, the sulphur, in contact with a portion of the oxygen of the nitre, forms sulphuric acid, which acting upon the base of the nitre liberates a portion of nitrous acid; this again is decomposed by the vapours of sulphurous acid into nitrous gas, which being but little denser than atmospheric air, and now expanded by the heat, rises to the top of the chamber, where meeting with a fresh dose of oxygen from the common air, again becomes nitrous acid vapour; this, again, being a very heavy æriform body, again precipitates on the sulphurous flame, and converts it into sulphuric acid; while again returning to the state of nitrous gas, it re-ascends for a further portion of oxygen, and again falls as before.

Thus by the alternate changes of nitrous vapour from the state of oxide to acid, the combustion of the sulphur and consequent formation of sulphuric acid is kept up until no more undecomposed common air is contained in the chamber, when a fresh portion must be let in by the side openings. The principal dexterity here required is to apportion such a quantity of sulphur and nitre to the size of the chamber that a renewal of both shall be required at one and the same time. When the water at the bottom of the chamber has absorbed such a quantity of acid gas as to raise its specific gravity from 1 to between 1.3 and 1.4, it is drawn off by means of stop-cocks, and subsequently evaporated in leaden boilers until of the proper density.

Sulphur was formerly much used in the bleaching-grounds, but since the introduction of the chloride of lime it is now generally laid aside. In combination with arsenic it forms two pigments, as mentioned under the head of that metal; it is also used in medicine.

MINERAL WATERS.

Those waters which contain such a quantity of saline or other foreign matter, as to be sensible to the taste, are termed mineral. They are found more or less in every country, and vary considerably in their composition, consequently in their action on the animal economy. Mineral waters are generally divided into four classes—Hepatic, carbonated, chalybeate, and saline. The first, or hepatic, are characterized, and therefore readily distinguished by a strong disagreeable smell, similar to that of rotten eggs, indicating the presence either of sulphuretted hydrogen or an hydrosulphuret. Under this class is also included those waters found near volcanoes which contain sulphurous acid, and which emit the odour of a sulphur-match when burning.

Carbonated waters are those which hold in suspension a large proportion of carbonic acid, and generally distinguished by an evo-

lution of gas, which is seen to arise to the surface of the glass immediately after the water has been withdrawn from the spring, as in those of Seltzer and Pyrmont. These are not to be classed with waters giving off a small quantity when heated, as every water, upon exposure to the atmosphere, will be found to imbibe a certain portion of this gas. Mineral waters, containing a great excess of carbonic acid, have the property of reddening vegetable blues, but upon the application of heat the colour of the test returns to its original tint.

Chalybeate waters are those which contain some salt of iron, likewise called ferruginous waters; they possess a strong metallic taste, changing to a deep brown or black colour upon affusion on tea-leaves, or any other astringent vegetable matter.

The fourth class of saline waters, contain variable quantities of muriatic and sulphuric salts generally with base of lime, soda, and magnesia. The purgative waters of Cheltenham and Epsom, are striking varieties of this class of mineral waters.

The following is a list of the substances found in the different mineral waters:—

Sulphuretted hydrogen	Sulphurous acid
Carbonic acid	Boracic acid
Oxygen	Soda
Azote	Silica

Hydrosulphurets of lime and soda,
Carbonates of lime magnesia, ammonia, potassa and iron,
Sulphates of soda, lime, magnesia, ammonia, potassa, alumina, iron, and copper,
Muriates of ammonia, soda, potassa, magnesia, lime, alumina, manganese, and barya,
Nitrates of lime, potassa, and magnesia,
Subborate of soda,
Vegetable matter,

Free oxygen and azotic gases, are seldom found in any great quantity in mineral waters. They cannot be contained in those denominated thermal or hot springs, neither can oxygen exist in sulphurous or sulphuretted waters.

Boracic acid occurs in some of the lakes in Italy; and the subborate of soda in the waters of a lake in Tibet.

Silica is found in the Carlsbad, and some other waters: soda in the Guysers, and the Rykum in Iceland.

Besides these substances, a mineral water may contain metallic salts of various kinds, arising from the passage of the water over beds of different ores. Thus the waters which run from many of the copper and iron mines, contain a considerable quantity of these metals generally held in solution by the sulphuric acid; the solvent in this case being obtained from the union of the sulphur contained in the ore with the oxygen of the water, a portion of which is therefore decomposed. They may also contain alum, sulphates and muriates of ammonia, and occasionally the nitrates of lime and potassa; but these last are of rare occurrence.

Those substances which most frequently occur in mineral waters, are the carbonates of lime, soda, magnesia, and iron, held in solution by excess of acid, and the same united with the sulphuric and muriatic acids. The whole of these however are not to be expected to exist in one spring, or to be contained in any large quantity.

Assay.

The first step necessary in the assay of mineral waters, is to determine exactly their specific gravity, compared with that of distilled water: and by which some idea may be formed of the quantity of saline matter contained: also if they emit any peculiar odour, whichwill be the case if sulphuretted hydrogen or an hydrosulphuret is contained. Their presence is likewise indicated, on adding to the water a few drops of any solutions of lead, by which it will be immediately blackened.

The next process is to bring a portion of the water to the boiling temperature, those substances which have been kept in solution by an excess of carbonic acid will now fall; this operation will also shew whether sulphuretted hydrogen, or an hydrosulphuret, (supposing the peculiar smell before alluded to, to have been observed) is contained; as if the former they will not now blacken solutions of lead, but if the latter, the effect will be undiminished.

If the substance thrown down by boiling is of a yellowish colour, carbonate of iron is

probably contained; to ascertain this, redissolve the precipitate in a little nitric acid, and drop into the solution a little prussiate of potassa, a blue precipitate will immediately ensue if this metal is present. Besides carbonate of iron, there will most probably be carbonate of lime; a part of the nitric solution is therefore to be added to one of the oxalate of ammonia, when if a white insoluble precipitate fall, the presence of this substance may be inferred. Should any thing however remain after the action of the nitric acid, it will probably be either silex or sulphate of lime: for the method of ascertaining which, see the articles Silicium and Calcium.

The water, after it has been boiled, should be examined, for every other substance which it is probable it may contain; and these are the different earthy and some few metallic matters, permanently held in solution by the fixed acids, such as the muriates, sulphates, &c.

Muriates are readily distinguished by the white flocculent precipitate, which ensues on the addition of any solution of silver, and which is soluble in ammonia, but insoluble in nitric acid.

Sulphates give, with the solutions of the nitrate or muriate of bary, a white salt, insoluble in excess of acid.

Nitrates, upon the addition of a small quantity of a solution of potassa to waters holding nitric salts, subsequent filtration, and evaporation, a salt will be obtained, which scintilates upon burning coals; it may also be detected by adding a little murio sulphuric acid to the dry mass dissolving in water, and boiling a slip of gold leaf in the mixture; if any portion of this metal is taken up, the presence of nitric acid may be inferred.

If the base of the salt in solution be lime, it will be indicated as before-mentioned by the oxalate of ammonia; if magnesia, the water will be rendered turbid by the addition of ammonia; or, what is better, add a solution of the carbonate of ammonia, and boil,—a precipitate of carbonate of magnesia will be obtained. If this body is contained, the water will be rendered turbid by boiling.

Salts, with base of alumina, are detected by the bulky and gelatinous mass produced on the addition of ammonia, soluble in caustic potassa and sulphuric acid; also by the pro-

duction of crystals of alum, by the addition of a solution of potassa, and a subsequent evaporation.

If any fixed salt of ammonia is contained in a mineral water, the residue left, upon evaporation, if mixed with a small portion of pure lime and heated, will evolve the peculiar pungent odour of this substance.

If the sulphates of iron or copper are contained in a mineral water, the first will give a black precipitate with tincture of galls, and a blue with prussiate of potassa; the second blue with caustic ammonia, and a film of metallic copper, on the immersion of a plate of iron.

Carbonates of potassa and soda, if these are contained, they will be known by the change of tint produced on the different vegetable colours the reds (except litmus), changing to green, and the yellows to brown; but as these salts are seldom contained except in minute quantities, it is generally necessary to concentrate the water by evaporation. The dry residue thus left, effervesces, and produces soluble salts, with the different acids, easily distinguished from those with any other base.

Analysis.

Sufficient having been said to enable any person to ascertain the probable contents of a mineral water, the method to be pursued in analysis will now be given, leaving the reader, who may wish to pursue this more intricate department of chemical science, to refer to the works of Thenard, Berzelius, Klaproth, Henry, Thompson, and many other chemical writers, where the subject is treated at large. Supposing, therefore, that a water contains either carbonic or sulphurous acids, oxygen, azote, or sulphuretted hydrogen, besides other but not volatile bodies, proceed as follows:—

Process 1.—Provide a bolt-head or matrass capable of holding about two gallons of the water, furnished with a perforated stopper, and from which a bent glass tube proceeds, dipping into a solution of ammonia and muriate of lime, contained in a two-necked receiver. Another tube, bent at right angles, and proceeding from the other neck of this vessel, is to communicate with a pneumatic trough, where any gas, not absorbed

by the mixed saline solution, will be collected. The bolt-head, containing the mineral water, should now be placed in a sand-bath and heated, until the whole of the gases have been expelled,—care having been previously taken that the different parts of the apparatus have been cemented together air-tight. The carbonic acid now passing through the solution will be absorbed by the ammonia, and afterwards separated in a combined state by the muriate of lime. Separate by decantation the carbonate of lime thus formed, wash and dry it; 100 parts are equal to 43.5 carbonic acid.

2.—Provide a tubulated glass retort, holding about four ounces; and having half filled it with a mixture of common salt and black oxyde of manganese, in the proportion of three of the former to one of the latter, pour in by the tubulure sulphuric acid, diluted with half its weight of water, until the quantity of real acid doubles that of the manganese employed. Pass the chlorine thus eliminated, first through water contained in a two-necked bottle, by which it will be purified, and afterwards by a bent glass tube into

a bottle containing a given portion of the mineral water under examination. By this means the sulphurous will be changed into the sulphuric acid, which, on the addition of nitrate of Barya, will be precipitated in the form of an insoluble white powder, or sulphate of Barya, 100 parts of which are equal to 34 of sulphuric, or 27.5 of sulphurous acid.

3.—To ascertain the quantity of oxygen and azote contained in a water, fill a retort with it, and introduce the end of the neck, also filled with water, under a graduated receiver placed in the mercurial trough; upon the application of heat the gaseous content will be given off and collected in the inverted jar. To determine the quantity of each of the gases thus collected, take a few grains of phosphorous; and having inserted them into a bent glass tube, sealed at one end, introduce the other beneath the jar containing the mixed gases; upon the application of heat to the sealed end, phosphorous acid will be evolved, and which, rising into the jar, will absorb the whole of the oxygen contained, leaving the azote behind. The difference in volume will now give that of the oxygen.

Should the water have contained sulphuretted hydrogen, a little solution of caustic potassa should be sent into the jar, and the vessel gently shaken previous to the phosphorus being applied.

4.—Waters containing sulphuretted hydrogen should be put into a flask, furnished with a bent neck, one end of which passes into a sulution of acetate of lead; upon the application of heat, the gas will be expelled and will combine with the lead in solution, every 100 grains of dry sulphuret of lead, thus precipitated, are equal to 13.4 of sulphur.

Process 1.—The quantity and nature of the different volatile bodies contained having been estimated by the previous processes, evaporate a gallon of the water to one-fourth its bulk, in a perfectly clean and well-tinned copper vessel, taking care that no particles of dust get into it during the evaporation. Transfer the remaining quart with any adhering dry salt that may stick to the sides, into a glass or porcelain vessel, and evaporate with gentle heat to dryness.

2.—Digest the dry mass obtained in the last Process, in a small quantity of distilled water;

if any remain behind insoluble, it must be separated by the filter, washed, dried, and labelled, "Matter insoluble in water."

3.—Evaporate the aqueous solution in Process 2 to dryness, and endeavour to effect a solution in alcohol; separate what remains, and label, "Matter soluble in water." The remaining, or third portion, will be that soluble in alcohol.

4.—The dry mass insoluble in distilled water, and collected in the second Process, will probably consist of silica and sulphate of lime, besides the carbonates of iron, lime, and magnesia. To separate these, digest the whole in dilute muriatic acid; taking care to avoid adding any great excess of this solvent, dilute with water, and throw the whole on a filter; what remains is the sulphate of lime or silica, or both combined, and these are to be separated by boiling them in a solution of carbonate of potassa, which will decompose the sulphate of lime, forming a carbonate easily taken up by muriatic acid, whilst the silica is left behind. The muriate of lime formed, may be again changed into its original state of sulphate, by adding sulphate of soda in

excess; collect the products, wash, dry, and estimate their quantities.

The lime, magnesia, and iron, remaining in solution in the muriatic acid, are partly separable by the addition of caustic ammonia, which will throw down oxide of iron; after separating which, drop in sulphuric acid, evaporate to dryness, and digest the residue in distilled water; what remains will be sulphate of lime, the weight of which will determine that of the sulphate of magnesia, and the relative quantity of base ascertaind by the scale, or it may be brought again to the state of carbonate, by boiling with carbonate of potassa.

6.—The salts existing in the native state, and soluble in water, are the muriates of soda and potassa, and nitrate of potassa, the sulphates of magnesia, ammonia, soda, copper and iron, and the sulphate of alumina and potassa, (alum,) the boracic acid, and subborate of soda, carbonates of soda, and potassa.

The salts soluble in alcohol, and likely to exist in a mineral water, are the muriates of soda and ammonia, the hydro-sulphuret of soda, the nitrates and muriates of magnesia and lime, and free soda.

The separation of the whole of these salts, supposing them to be contained in one description of water, would be extremely tedious. But as this is never the case, a water seldom containing more than four soluble salts, often not more than two, and as these are chiefly muriates of soda, and sulphates of soda and magnesia, their analysis is not always attended with the difficulty sometimes imagined. Carbonate of soda is also a very common ingredient in mineral waters, but is incompatible with the sulphate of magnesia, the base of which it would precipitate, at the same time that sulphate of soda would be formed.

Process 1.—Supposing a mineral water, therefore, to contain, besides the gaseous bodies and the insoluble matters, (sulphate of lime, silica, &c. the separation of which has been already mentioned), the sulphates of magnesia and soda and common salt. And supposing these three to have been obtained in a dry state by the evaporation of the water, subsequent solution and desiccation, digest the whole in repeated portions of good alcohol until nothing more is taken up, or until the solution of the residue in water furnishes

no precipitate with nitrate of silver; dry and weigh the residue.

2.—Dissolve the sulphates of soda and magnesia in water, and drop in cautiously a just sufficient quantity of muriate of barya to decompose the whole of the sulphate salts; collect the sulphate of barya thus formed, wash, dry, and estimate the quantity of sulphuric acid contained; 100 parts of the dry salt are equal to 34 of sulphuric acid.

3.—The muriates of soda and magnesia, the result of Process 2, may be partly decomposed by heat in a platina crucible; magnesia and muriate of soda will remain; they may be separated by solution in water and filtering, which will leave the hydrate of magnesia, the quantity of which, when dried and added to its equivalent of sulphuric acid, will give the quantity of this salt originally contained in the water.

4.—The muriate of soda of the last Process, but originally a sulphate, may be again regained in its former state, by mixing it with a sufficient quantity of strong sulphuric acid in a platina crucible and subjecting to heat; by this means, the muriatic acid will be got rid

of; its weight may now be taken and put down as the sulphate of soda existing in the water; care having been taken to drive off any superfluous acid that may have been added; or the equivalent quantity of soda existing in the muriate, may be taken and added to that of the sulphuric acid, required for its saturation.

5.—The analysis may now be finished by evaporating the alcoholic solution in Process 1 to dryness, and taking the weights of all the different ingredients.

Analysis of a Water containing Carbonate of Soda.

Process 1.—If a mineral water, similar in other respects, but containing carbonate of soda, instead of sulphate of magnesia, separate the muriate of soda as in the preceding analysis. Collect, dry, and estimate its quantity.

2.—Add muriatic, or what is better acetic acid to the residue, until no further extrication of carbonic acid takes place; dry this residue, and digest again in alcohol, which will take up the muriate or the acetate; the composition of

which may be readily ascertained, the sulphate will now be left behind.

It is to be remembered that in the analysis of waters containing muriate of soda, that this substance is much more soluble in water than in alcohol; and that, therefore, on this account, many digestions with this latter menstruum are necessary, if its separation by this method is wished.

By the foregoing examples it will appear that the analysis of the waters generally met with is sufficiently simple to be easily performed—supposing that the method of evaporating them down to dryness, and after separation of the mass so obtained into its different constituent parts, is correct: but as by this method, when many salts are in solution, results are obtained which do not always agree with the prior examination of the water, many circumstances (which will always vary with the salts contained) must be taken into consideration. Many chemists adopt the plan of separating the salts from one another, by their relative degrees of solubility, thus collecting them, by very gentle evaporation of the water, in the crystallized state, the de-

terminate figure of the crystals being sufficient to enable the operator to distinguish and separate the one from the other. But although this method answers very well, to a certain degree, yet a very great difficulty, if not impossibility, will be experienced in the separation of the last portions. Another plan, after determining the constitution of the water, and collecting the gases, is to add successively certain tests, the base of which, combining with the fixed acids of the salts in solution, will precipitate them, at the same time that the acid of the test unites with the base of the salt; thus, if the acetate of barya is added to a mineral water containing the sulphates either of soda or magnesia, sulphate of barya will be precipitated, whilst acetate of soda or magnesia will be formed; and as acetic acid is not to be suspected in a mineral water, its introduction will occasion no obstacle in the after stage of the analysis, which might be the case if either the muriate or nitrate of barya had been added, these acids, in a combined state, being probably contained. The acetates are also generally soluble in alcohol, and are readily decom-

posed, and their bases obtained, by exposure to a low red heat,—two very great advantages in this species of analysis. After the solvents of the bases of the salts have been thus obtained, the separation of the bases themselves is effected, and by this means results more nearly approximating with the true nature of the water under examination can be obtained than by evaporation to dryness in the first instance; but this depends, as before stated, entirely on the nature of the salts contained. The last stage of the analysis, performed in this manner, will of course consist in ascertaining the equivalent quantities of the different binary compounds formed; in estimating which, the scale of equivalents will be found of considerable utility.

The analysis of mineral waters is perhaps the most tedious, if not the most difficult of any, that of vegetable substances, and concerning which very little is, comparatively speaking, known, being excepted. Indeed the various methods adopted in their examination, often lead to discordant results, and this, coupled with the small quantities generally contained, renders the collection to that nicety which is so essential in analysis, a mat-

ter of no small difficulty. The utility of determining the composition of waters, as far as their assay implies, is doubtless often considerable; but how far the term is applicable, in a general point of view, to their exact analysis, remains with the reader to judge; a perusal, however, of the authors before alluded to, will more amply illustrate this subject.

THE END.

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Do. with concentric wicks . . . . . £1 8*s*.
Do. (Spirit) with or without ground glass caps 4*s*. 6*d*. to 7*s*.
Air Pumps, double barrelled . . . . . £8 8*s*. to £10.
&c. &c. &c.

CHEMICAL PREPARATIONS FOR PHILOSOPHICAL AMUSEMENT.

Fulminating Silver, which explodes by friction. 2*s*. *per paper.*
Fulminating Mercury, which, when struck with a hammer on an anvil, explodes with a stunning report.
1*s*. 6*d*. *per box.*
Fulminating Gold . . . . . 5*s*. *per paper.*

A Powder which takes fire when forcibly rubbed with a pestle in a mortar, and inflames with a rapid flash like fired gunpowder . . . . . 1*s.* 6*d. per box.*

Powder of Fusion, by means of which coin may be melted in a nut-shell . . . . . 1*s. per box.*

Auriferous Ether, for gilding, highly polished by mere immersion. . . . . 2*s.* 6*d. per bottle.*

Silvering Powder, for silvering copper or brass by friction. 1*s. per bottle.*

Gold Powder, for gilding silver by friction . 1*s. per bottle.*

Fusible Metal, which melts under boiling water, and remains fused as long as the water is kept boiling . . . 9*d. per oz.*

Spoons, of the same metallic alloy . . . . . 9*d. each.*

Sympathetic Ink, which, when written with on paper, is and remains invisible whilst kept in the dark, and becomes visible when the writing is exposed to the light of day, or the direct rays of the sun . . . . 1*s. per bottle.*

Blue Sympathetic Ink. Writing made with it are invisible when dry, but speedily assume, when held before the fire, a greenish blue colour, which again departs as the paper becomes cold . . . . . 1*s.* 6*d. per bottle.*

Yellow Sympathetic Ink. Characters written with it when dry are invisible, and may be made to appear or to depart successively, by alternately warming the paper, or suffering it to cool . . . . . 1*s. per bottle.*

Green Sympathetic Ink . . . . . 1*s. per bottle.*

Two Transparent Fluids, which, by mixture, instantly become converted into an opaque and almost solid mass.

1*s.* 6*d. per bottle.*

A Mixture of Nitrate of Strontia and Alcohol, which, when set on fire, burns with a carmine red flame.

1*s.* 6*d. per bottle.*

A Mixture of Nitrate of Copper and Alcohol which, when set on fire, burns with an emerald green flame.

Frigorific Mixtures, for freezing water in the midst of summer, or near a fire . . . . . 2*s.*

Phosphoret of Lime, which, when thrown into water, causes bubbles of gas to issue therefrom, which take fire at the surface with a brilliant flame and snapping noise. 2*s.*—3*s* 6*d.*—and 5*s. per bottle.*

Oxygenized Matches, which take fire the instant they are immersed into sulphuric acid . . . . 1*s. per hundred.*

Nitrate of Copper, for setting tin foil on fire . 1*s. per bottle.*

Solution of Silver, for illustrating the astonishing divisibility of matter. . . . . 1*s. per bottle.*

Fire powder, which inflames by a drop of sulphuric acid. 1*s.* 6*d. per box.*

Solutions for the Microscope . . . . . 12*s. per dozen.*

Phosphorized Ether, which of itself is not luminous, but renders warm objects, to which it is applied, luminous in the dark, in stop bottles . . . . . 1*s.* 6*d.*

Phosphorized Oil renders bodies luminous in the dark, and gives sufficient light to admit of the hour being seen on the dial of a pocket watch during night: in stop bottles, 1*s.* 6*d.*

Oxide of Phosphorus, when applied to a sulphur match sets it on fire by friction. . . . . 2*s. per bottle.*

Phosphoric Fire Bottles, ditto . . . . . 6*d.*

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Mineral Chamelion, which tinges cold water green, purple, and red; and hot water pink, and crimson, 1*s. per bottle.*

Liquid Bronze, for instantly bronzing copper, brass, &c. 1*s. per bottle.*

Wine Test, for detecting the deleterious adulteration of wine, cyder, &c. . . . . 2*s. per bottle.*

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Preparations for making, instantly, Seidlitz, Seltzer, or Soda water . . . . . 2*s.* 9*d. and* 4*s.* 6*d. per box.*

Bleaching Liquid, for discharging stains of red wine, tea, fruit, mildew, &c. out of linen, muslin, cambric, lace, and other articles, and for restoring linen or cotton goods, when discoloured by age, washing, &c. to their original whiteness . . . . . 2*s. per bottle.*

Permanent Ink, for marking with a pen, linen, cotton, &c. which no art can efface . . . . . 2*s.* 6*d.*

Preparations for forming the (so called) Arbor Dianæ, or silver tree . . . . . 4*s. to* 7*s.*

Preparations for forming the lead tree . . . . . 1*s.*

Fluor Spar, for etching on glass . . . . . 1*s. per lb.*

Solution, for showing the precipitation of silver in a brilliant metallic and arborescent form . . . . . 1*s.*

Amalgam, for silvering the internal surface of glass globes. 6*d.* [illegible].

Lycodium, for producing artificial lightning . 1*s. per box.*

Pyrophorus, which burns spontaneously on exposure to air, and when poured into a jar of oxygen gas forms a brilliant fiery shower . . . . . : [illegible]6*d.*

Bologna Vials, ... 18*s. per doz.*

Rupert's drops . . . . . 8*d. per dozen.*

Joyce's Descriptive Priced Catalogue of Chemical Tests and Apparatus, containing an alphabetical list of every article under experimental chemistry. *Price* 1*s. with a plate.*

LIST,

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FOR CARRYING ON

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A PORTABLE universal furnace, with its appendages, namely, crucible and fire tongs, shovels, sand bath, muffle, iron rings, ladles, &c.—A table lamp furnace, with spirit lamp, and a sliding stand.—A pocket blowpipe, with platina, forceps, platina foil and blowpipe spoons.—A mercurial thermometer —A spirit thermometer.—An air thermometer.—A freezing apparatus.—A brass stand, with sliding rings, for supporting retorts, flasks, basons.—A pneumatic trough, adapted for the table, with an assortment of air-jars, bell-glasses, deflagrating jars for operating on gases, &c.—An air-holder for collecting and preserving large quantities of gases.—A wide-mouthed globular receiver for experiments on gases.—Dr. Hope's eudiometer.—A spirit lamp.—Gas bottles, with bent tubes.—A cast iron retort and flexible metal tube, for obtaining those gases which require for their production a red heat.—A bell-glass mounted with stop cocks and bladder.—An eudiometer tube for experiments on gases.—A brass wire stand, with leaden foot.—A chemical lamp on Argand's plan.—A gun

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This much admired article, which has now stood the test of experience, will be found by every sportsman using the percussion principle, not only to be superior to any other at

present or hitherto used, but to possess other and very important qualifications. On a moderate calculation, a gun using this powder as a detonater, will last three times as long as one fired with powder of the chlorate of potassa composition. It may be had in the various forms of caps, patches, balls and grains, either at the laboratory, Old Compton Street, or of most respectable gun makers in town and country. It is warranted not to miss fire, and to be effective in every climate.

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The whole of the extracts used in medicine in a perfectly pure and dry state, *packed in* bottles of any size.

The above are manufactured on the new and improved principle of steam in *vacuo*, and are furnished to the medical practitioner either in the state of a fine powder, or in that of scales:

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This preparation is well worth the notice, not only of those persons who are accustomed to take the decoction of sarsaparilla, but of the medical practitioner, as he will find the sarsaparilla Chocolate to possess two essential requisites; a degree of strength not inferior to the compound decoction of the London Pharmacopœia, and at the same time, if taken according to the directions, a flavour which will not nauseate on the weakest stomach. Sold in Packets, making one and two quarts each, price 4s. 6d. and 9s.

DESCRIPTIVE CATALOGUE.

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Nitric.
Nitrous.
Oxalic.
Prussic (Hydrocyanic).
Pyroligneous.
Sulphuric.
Tartaric.
Æther Sulphuric.
Nitric (Sps).
Ammonia Lign: Fort.
Carbon.
Ammoniated Alcohol.
Argenti Nitrat.
Bismuth Muriate.
Oxide.
Calcis [redacted]. (Oximur.)
Murias.
Cinchon. Sal Essent.
Ext. Sarsaparil. Comp.
facere. Decoctum.
Ferri Sulph. Purif.
Hydrarg. Chlor. (Oximur).
Nitric Oxide.
Oxyd. Rub.
Præcip. Alb.
Submur.
Sulphat.
Iodine.
Tincture.
Magnes. Ust.
Potass Acetas.
Arsenias.
Carbonas.
Citras.
Chlorat (Oximur).
Nitras, purif.
Sulphuret.
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Super Acet.
Soda Tartras.
Boras.
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Sulph. purif.

*** *The articles in the above List are manufactured for the use of Medical Practitioners and Druggists: They will be found of the best manufacture, and at the most reasonable prices.*

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